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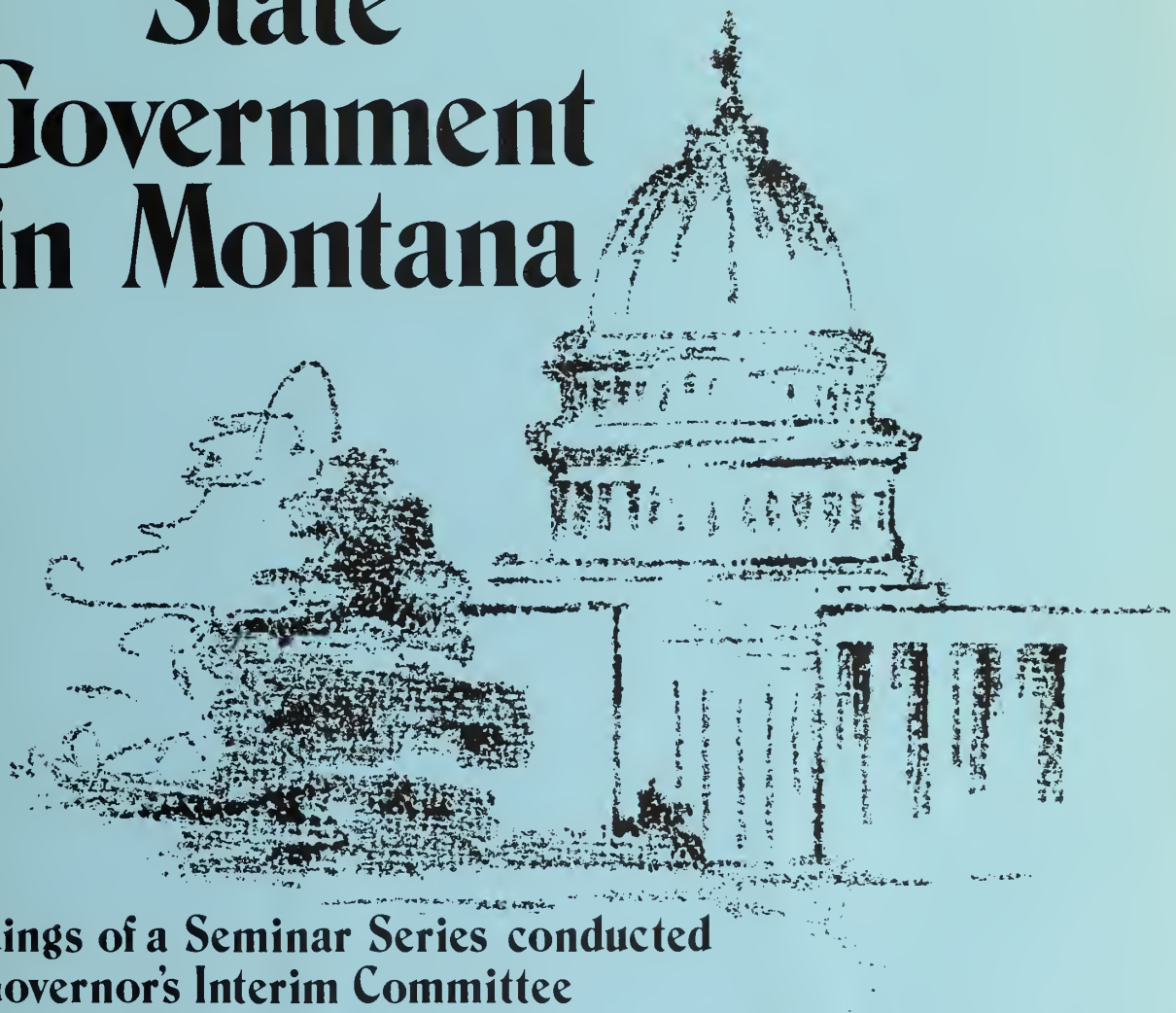

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SCIENCE, TECHNOLOGY AND STATE GOVERNMENT IN MONTANA

Proceedings of a Seminar Series Conducted
by the Governor's Interim Committee
on Science and Technology
In Cooperation with
The National Science Foundation

Montana State University

Bozeman, Montana 59715 Tel. 406-587-3121

Office of the President
Carl W. McIntosh, President
Wm. A. Johnstone, Vice Pres. for Administration

Roy E. Huffman, Vice Pres. for Research
I. E. Dayton, Vice Pres. for Academic Affairs

June 10, 1971

Honorable Forrest H. Anderson
Governor of Montana
Capitol Building
Helena, Montana 59601

Dear Governor Anderson:

I am pleased to transmit to you the proceedings of the seminar series entitled Science, Technology and State Government in Montana. The series of four seminars was carried out during 1970 by the Governor's Interim Committee on Science and Technology under the provisions of a grant of $10,000 from the National Science Foundation. The seminars emphasized the potentials for use of science and technology in agriculture, forestry, mining and government.

The papers contained in these proceedings cannot reflect all of the information and ideas exchanged and discussed during the course of the seminars. This publication should be a valuable reference, however, for the participants in the seminars and those unable to attend.

Sincerely yours,

Roy E. Huffman
Science Advisor and
Chairman of the Governor's
Interim Committee on
Science and Technology

FORREST H ANDERSON
GOVERNOR

State of Montana
Office of The Governor
Helena 59601

June 24, 1971

To: The People of Montana

This report from the Governor's Interim Committee on Science and Technology is a collection of papers presented at a series of four seminars on potentials for the use of science and technology in Montana. Recommendations of the Interim Committee to me are also included in this report.

Science and technology will become increasingly important components of the growth and economic development of Montana. Science and technology are also major factors in the maintenance of environmental values in Montana. Participants in the seminars gave special attention to the interrelationships between economic development and environmental values.

I commend this report to you for your study and consideration. We appreciate the grant of funds from the National Science Foundation that made it possible to present this evaluation of the potentials for the use of science and technology in Montana.

Sincerely yours,

FORREST H. ANDERSON
Governor

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POTENTIALS FOR SCIENCE AND TECHNOLOGY IN AGRICULTURAL DEVELOPMENT

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Research Assistant and Professor, respectively
Agricultural Economics
University of California at Davis

It is frequently assumed that science and technology, while not providing answers to all our present day problems, can still solve most of them. Such an optimistic view must be tempered with considerable caution. Many of our most pressing current day problems such as unemployment among the unskilled and environmental pollution have arisen largely as a result of advances in science and technology. Given the complex social and economic dimensions of these problems there can be little optimism that more doses of technology, haphazardly applied, will solve them. Further technological advance will likely create yet more complex problems.

In this paper we show that science and technology have had a highly significant positive effect on agricultural production in the past, and are likely to do so in the future. That they have also been responsible for a number of social costs which have largely been ignored both by those responsible for developing the science and technology and those who have applied or adopted it will be shown. This raises several questions concerning how findings from research and development can result in an increase in productivity and how changes in productivity are measured. These problems are examined briefly in the development of concepts and definitions.

The economic and social conditions in the United States have strongly encouraged steady agricultural development and agriculture has contributed heavily to the general economic and social advance of the country. We discuss briefly how science and technology are related to this developmental process. We then turn to some sources of new information which can be expected to lead to further development in the future.

Private and public research should have complementary roles in supplying new information. Public research can and should investigate those aspects in an entire system which would be influenced, beneficially or adversely, by the introduction of any new technology. In this way, some of the pitfalls which have arisen in the past as a result of narrowly directed research efforts might be avoided. To illustrate the necessity for looking at the benefits and costs on a broader base than has been done in the past, we discuss three examples of advances in agricultural productivity traceable to application of technology where the social consequences, and, to some extent, the economic consequences have been overlooked.

Concepts and Definitions

Since 1870, agricultural output in the United States has increased sixfold.[1] Part of this is a result of the historical expansion of farming activities. By increasing all inputs proportionally, including

land, output increased roughly in the same proportion. As an example, consider the development of land in these Western States during the last century. Because of high transport costs to population centers, much of this land was on or beyond the margin of cultivation. Rising food prices, and, more particularly, cheapening transport costs as a result of improved transportation brought first the most productive land, then successively less productive land into cultivation.

Another part of the output increase was also encouraged by economic forces and became important once land extensification ceased. This is the part caused by physical changes in the relative quantities of inputs used. For example, fertilizer use has increased sharply and machinery has replaced labor to a large extent. These changes are caused by shifts in the price of one input relative to another and relative to the prices of outputs.

Input and output indexes are typically used to study changes in productivity. Since comparisons over time are desired, inputs and outputs must be measured in common terms (dollar value) but in real terms from some base period where they are set equal. The productivity index is defined as the ratio of outputs divided by inputs. But the appropriate choice of inputs and outputs depends on the purpose of the productivity index. We wish to measure technological change or, as an economist would express it, the magnitude of the shift from an original production function to a new one.

To aggregate the physical quantities of production of various kinds or of inputs of various kinds into either an output or input index requires a system of weights. Usually the weights are the prices in the base period. However, over time, relative prices of the inputs will change, and with them the proportions in which inputs are used. But the weights are constant, thus some commodities are overvalued and others undervalued as the mixes change through time. This problem is characteristic of productivity measurements and difficult to correct.

In some way, technology is responsible for the change in productivity. Unfortunately, as Schultz pointed out, "technological change, as the term for describing the dynamics of economic growth is subject to serious limitations because its components are distinct, dissimilar and unequal."[2] Thus, technological change does not simply reflect improvement in quality of the inputs, or in the change in productivity. Some of the physical changes, as for example, a change in the level of fertilization for a particular crop, may occur as a result of new information gained from research.

We must distinguish, therefore, between the production of new information and the change in output with respect to inputs which is what we usually measure when we measure productivity. It would be convenient to designate the production of information as technological change and the change in output as technical change.[3] Unfortunately, in common usage, the two terms are synonymous.

Research, development, invention and engineering constitute a spectrum of information producing activities. Both private firms in the agricultural input sector and university agricultural experiment stations conduct activities in the full spectrum. It is a common oversimplification to view basic research, development and engineering in a successive

relationship, although these may occasionally appear to be linked. Rather, each investigative phase adds some new information to the stock or pool of knowledge which then becomes available to all. How this new knowledge may be used may appear to be almost random as we will illustrate in one of the later examples.

To have an influence on production, new information must be disseminated. In agriculture this has traditionally been performed by the agricultural extension service, although representatives from private firms are playing an increasing role. The first farmer in a locality to adapt a new technique is the innovator. His main motivation is to increase profit or reduce risk. If his expectations are realized, he will enjoy extra profits or greater security which will induce his more cautious or less imaginative neighbors to follow suit. This is the basis of Cochrane's treadmill theory. Once a substantial number of imitators have adopted the new technique, the result will be a tendency to increase output, for as Ruttan noted, "Innovations designed to lower costs, . . . have a curious propensity to result in expanded output. . . (and hence lower prices) under free market conditions."[4] The net result is that all farmers are forced to adopt the new technique in spite of the fact that the final result may be to leave them all worse off. The temporary solution historically which seems almost to have become permanent with some commodities, has been to institute policies of acreage limitation and price supports.

Agricultural Development in the United States

Both the historical development of agriculture and its future potential can best be examined by disaggregating output into four components[5] and examining what has happened and what may be likely to happen to the major components. The four components are (1) value of crop production net of seed production, plus (2) pasture production at cost, plus (3) value added by all livestock, i.e., sales less feed costs, less (4) value of farm produced power (horses and mules) at cost. The latter enables the impact of the reduction in numbers of draft animals to be shown. The changes in crop production can be further disaggregated to that part attributable to changes in cropland acres and that to increase in crop production per acre.

The history of United States agricultural development is conveniently studied in three periods: (1) 1870-1920, (2) 1920-1935, and (3) 1935 to the present. The first period, 1870-1920, was marked by growth in output at a greater rate than total population growth. Thus we experienced a period of expansion in agricultural exports. Most of the increase in output was due to an increase in conventional inputs, the most important of which, particularly in the Western States, was the opening up of new lands. The amount of land and buildings used in farming more than doubled between 1870 and 1910.[6] The Homestead Act of 1862 was an important factor in encouraging land settlement, although certain of its limitational features have since become to be regarded by those concerned with economic efficiency as a hindrance to development, particularly on Federal irrigation projects. The amount of farm labor used almost doubled between 1870 and 1920,[7] while the numbers of horses and mules tripled,[8] showing a slight shift from human power to animal power during this period of expansion. The gasoline tractor was only just beginning to be introduced in 1920.[9]

The establishment of the Land Grant Colleges and the USDA in 1862, followed in 1887 by the establishment of the system of agricultural experiment stations laid the foundations for organized agricultural research. Most of the early research was adaptive in nature. There was considerable duplication of effort among the various State experiment stations, but the purpose of this work was largely to verify results observed elsewhere and convince local farmers of their practicality. This latter activity was greatly enhanced by the establishment of the Agricultural Extension Service in 1914.

The years 1920-35 were difficult years for agriculture. Output leveled off in the post-war slump of 1920-24. The great depression and the drought years in the 1930's took their toll so that output in 1935 was no higher than in 1920. Increase in land in farms was insignificant during this period. The most significant source of increased output was a fall in the horse and mule population (to 16 million in 1935).[10] This released land for cash crops or for producing meat animals and was responsible for 51% of the output increase from 1920-39.[11] It was made possible by an increase in tractor numbers to 900,000 in 1930 and to 1.5 million in 1940.[12] Increased mechanization, particularly for harvest operations, led to improved timing of operations and a reduction in the labor force. For example, in 1920, 5% of the wheat was harvested by combine; in 1933, 50%.[13] There was some decline in farm labor after the post-war slump, but there was no real incentive for labor to move off the land until the recovery period began in the late thirties. Agriculture still provided a pool of surplus labor.

With the depressed state of agriculture, such fields as agricultural economics and rural sociology began to augment the traditional production orientation of research. Extension programs soon began to reflect these same interests.

The present surge in agricultural output began about 1935. Since that year farm output has doubled, yet this has been achieved without increasing the land base. Between 1955 and 1962, the size of surpluses of certain commodities has led to a reduction of 40 million acres of cropland--10% of the total--through the imposition of acreage allotments. The number of horses and mules has continued to decline (to 3 million in 1960 when reporting ceased).[14] This element is now of little importance as a source of output increase.[15] Machinery statistics show rapid increases until the middle 1950's. What these statistics fail to show is the continuing improvements in machine efficiency and capacity. It is these features which largely explain why total labor use in agriculture has fallen from 20 million man-hours per year in 1944 to 7.5 million in 1966.[16]

The most important source of increased output in the period from 1935 has been the increase in crop production per acre.[17] This has risen at an ever increasing rate and more than doubled over this period.[18] Increased use of fertilizer has been responsible for more than half the rise in crop production per acre,[19] and, because of the significance of the corn crop in total output, the introduction of new hybrids has accounted for one tenth of the increase.[20] Irrigation, although it greatly increases yields, has been introduced on a relatively small number of acres, and surprisingly is a relatively insignificant source.

In the Mountain States, much of the new acreage has gone into extensive crops, which has altered the composition of the output mix and almost exactly counter balanced the improvement in crop production per

acre caused by more and better inputs.[21] This downward biasing associated with expansion of extensive agriculture in many areas is also significant in the national aggregates.[22]

Agricultural research and extension expenditures continued to increase faster than farm output.[23] The most important feature in recent years has been the rapid rise in research and extension services performed by firms in the farm input industries. Expenditures on private agricultural research are difficult to obtain. A frequent assumption is that at present they constitute 50% of the total.

One other feature associated with the rise in technology should be mentioned. Substantial structural changes have taken place in agriculture, particularly in recent years. Two forms are of particular interest. One is the increase in size of farms, a trend which we anticipate will continue. Technical advances have continually pushed up the economic size of a unit. Most studies of economies of size consider a planning cost curve based on a set of the best techniques available at a particular point in time. One which specifically studied changes in the efficient size as a result of mechanization showed that cling peach orchards had declining costs per ton up to about 60 acres using conventional production practices, but that costs would decline to 90 to 110 acres using mechanical pruning, thinning, and harvest machines then being developed.[24]

The second form of structural change is increased specialization both by product and by function. One reason for product specialization is to take advantage of economies of size without having to increase the size of farm any more than necessary. Increased tenant farming of a type quite different from the traditional mode has developed concommitantly. Specialization by function can be illustrated by the rise in an industry which produces lay pullets for sale to the egg producers who now choose to concentrate solely on the improvement of the egg production process.

Farms may remain "family farms" but they become substantially complex business enterprises.

Future Changes in Agricultural Production

That aggregate agricultural output in the United States will increase in the future is certain. The rate depends primarily on population increase to shift demand and thus provide profitable market outlets. Agricultural output could increase using presently available technologies if the relative prices of inputs and outputs move to make increased land, fertilizer, and water use economically feasible. Four potential areas of further productive development--resource use, mechanization, crop production, and animal production will be briefly considered.

There is no shortage of land for cultivation. Of the 637 million acres of land, which is considered suitable for cultivation, a 1958 survey found only 60% of this actually under cultivation. Since then acreage allotments have forced a decline in cropland area. Projections to 1975 indicate that 11 million fewer acres will be under cultivation in that year than were farmed in 1958.[25]

No further increases in output as a result of the replacement of draft animals can be expected. But further mechanization will take place even though the remaining tasks are more difficult to mechanize. Emphasis on partial mechanization and relieving the physical exertion of labor will likely increase. More specialized harvesting machines will be developed. Experimental peach and grape harvesters, for example, are now being tested. In nearly all such cases, other cultural practices must be altered such as plant spacing and pruning or training in the case of trees and vines. Other tasks, such as sugar beet thinnning and tomato sorting which require much labor at times of peak demand will be further mechanized. As a greater proportion of the fruit and vegetable harvest goes for processing, better planning through the use of systems approaches is likely to be applied to improve the efficiency of getting the crop from the plant in the field into consumer containers. Reduction of field waste in perishable crops and post harvest losses holds great promise for increasing output.

The vacuum cooling of lettuce not only reduced the labor required in packing and shipping fresh lettuce, but reduced greatly the physical loss after harvest. The reduction in loss occurred both in packing for shipment and preparing for sale at the eastern retail outlet.

Irrodiation is a technique that holds great promise for increasing the shelf life of fresh fruits and vegetables. Much of the biochemical and physiological work is done for selected crops, but appropriate clearance with respect to human safety has not been given.

In crop production, record yields for most crops are considerably (4 to 8 times) higher than recent average yields[26] but are only 50% to 70% of the calculated potential maximum yield.[27] Increased use of fertilizers and expansion of the irrigated acreage would, with no new techniques, raise the average yields markedly. The greatest potential, however, is in new techniques.[28] Genetic improvement will be important. In plant breeding emphasis will likely be as much on improved quality as on yield increase. The new high-protein varieties of corn are examples. New cultural methods such as foliar feeding, better weed control, use of chemical growth regulators, more precise mechanized planting and harvest will no doubt increase output. A most important future source of increase should be in better crop protection during growth, handling and storage so that more of the product is actually consumed. The future in this area is not clear, for recent concerns over most pest and disease control materials have raised serious questions concerning their future use. Stricter controls are being invoked that could lead to some quality decline as a trade-off for lower residues or banning of some materials. Research on alternative approaches has not progressed as rapidly as many would like to see.

Livestock production shows great variation in the potential for improvement.[29] Record milk yields exceed the average by as much as eight times, but with egg production, the record is only one and one-half times the average. This reflects marked differences in recent advances in poultry sciences, and a far more sophisticated industry structure in which new information is quickly disseminated and adopted by producers highly conscious of market conditions.

Genetic improvement shows great potential. Again the approach is not just to find the highest yielders of milk or eggs, nor the fastest and most efficient converters of feed to meat, but also to select for

quality, for example, lean strains of hogs and beef animals with high meat to bone ratios. Increased prolificacy in cattle, sheep, and swine will be sought. Some of the more esoteric scientific discoveries such as the genetics of double-muscling in cattle may well contribute to marked increases in meat production. In short, there is great potential for the field known as "biological engineering".

Improved feeding, including control of rumen bacteria in cattle may increase production. Improvements in preventing animal diseases, both to cut death losses and maintain animal productivity, as well as safeguard consumer health will continue. In general, increases in livestock production are not expected to contribute as much as crop production to increased agricultural output.[30]

Forces Behind the Increasing Productivity

The cultural, social and legal institutions of the United States have created conditions highly conducive to development. We are a strongly market-oriented economy in which change is accepted as normal and desirable in the pursuit of increased efficiency. Progress, or economic growth has been a goal in itself. Stability, especially price stability, has been a conscious policy objective for the past several decades and has encouraged individuals to innovate. At the same time relative price changes have signalled the need for resource shifts in the interest of economic efficiency.[31]

Economic incentives for farmers to change (or not to change) are of three principle kinds. The change in relative prices, and particularly in the past, the reduction in the price of machinery relative to that of labor are one kind. These have resulted largely from reduction in prices as a result of technical change in farm input industries. Second are technological changes within agriculture which encourage an individual farmer to make changes which he expects will increase profits. The rate of adoption depends on the amount by which profits are expected to increase (or losses decrease).[32] Finally, limitations on the availability of credit to farmers will inhibit, and in some cases prevent, them from undertaking profitable changes, such as the purchase of a tomato harvester, which would result in reduced costs per ton.

Industrial development provides an outlet for surplus rural labor in a developing economy. Technological advances in farm input industries can lead to lower input prices for farmers and hence to greater use of these inputs by farmers. Yields and production tend to increase and, in the absence of commensurate increase in product demand, lower prices for farm products result. Ultimately incomes in agriculture are depressed, encouraging a migration to the cities. On the other hand, industrialization in which the increased production of farm inputs is included,[33] provides increased employment and rising wages which again accelerates the drift from the land.

Turning again to experience in California, this well reasoned and generally accepted pattern of economic growth and migration from agriculture to nonagricultural employment has not been clearly functioning. Those replaced in agriculture are not being absorbed in an urban economy demanding certain basic skills for employment.

The rate of adoption of new techniques is of critical importance in ensuring successful development. It depends on both social and economic factors. The values and beliefs which give rise to the institutions and goals described above play a fundamental part. A high level of education in rural communities and an active and responsible extension service are no less important.

Sources of Information for Development

Both the agricultural experiment stations and private firms can perform research and development which will supply information needed to raise agricultural output, but because of their different motivations, philosophies and organizations they should be encouraged to complement each other, rather than compete. The relation between the experiment station and the extension service should also be complementary.

Private firms are motivated to undertake research principally in order to maintain or increase profits and, therefore, are concerned with the development and expanded use of their own products primarily. University experiment stations, on the other hand, should support research which produces results with wide applicability. It should not be the role of a university to undertake research which can be carried out equally well by a private firm.

Publicly supported experiment stations, then, should perform three overlapping functions: (1) They should provide the kind of basic information which both public and private firms need to have to solve critical problems, but which private firms tend to avoid on the basis that its cost exceeds the direct benefits. Seed firms, for example, now do much of their own varietal development, but rely on university experiment stations for new germ plasm. (2) They should develop information likely to be of great public benefit but of little benefit to, and not apt to be undertaken by, an individual private firm. Research into the biological control of insect pests would be of this type. (3) They should monitor private and other public research to point out the existence of and possible magnitude of unconsidered costs and benefits of a technological change. This is a new and controversial role, but one of great potential. In California, a State heavily dominated agriculturally by large-scale enterprises, shifting of research resources away from primary production problems to socio-economic problems is not easy to accomplish. But, it is being done!

The extension service is in position to perform much of the adaptive research such as testing and selecting varieties suitable for local conditions, once the main activity of the experiment stations. In addition, it can continue to disseminate research findings to farmers increasingly in consort with fieldmen from various types of supply or processing firms.

Pitfalls to be Avoided: Some Examples

To illustrate the pitfalls of short-sighted or unduly restrictive research approaches, three examples have been chosen from the California experience. In each, the agricultural "growth" which followed the introduction of the science and technology was looked on as successful.

The broader implications were overlooked.

The first example concerns the impact of the adoption of new techniques. Increased mechanization, for example, may result in (1) lower incomes for farmers, and (2) loss of employment for a number of farm workers. It may also bring on new technical problems unforeseen prior to their appearance.

As an example of the loss of employment caused by mechanization, we can cite the introduction of the tomato harvester. The history of the development of this machine is a fascinating story, illustrating both a parallel research effort and a systems approach to research. Engineers and horticulturalists, aided by irrigation specialists teamed up to produce new varieties, cultivating methods and harvesting techniques.[34]

Hand picking of canning tomatoes is traditionally carried out three or four times during the ripening period. Early in the development of a mechanical system for this harvest, it was recognized that a once-over operation would be the most feasible. At the University of California, Davis, emphasis was placed on finding varieties that would ripen uniformly and withstand the rough handling of mechanical harvest. The search produced a pear-shaped variety which, however, was not acceptable to consumers when canned whole. As a result of a decade of plant breeding work, a round variety, VF-145, which had the desired characteristics of concentrated fruit set and disease resistance, was released in 1961. It now occupies 85% to 90% of the California canning tomato acreage.[35]

The basic genetic work was very largely completed as a result of a long standing project on the genetics of the tomato and its close relatives. What remained to be done was the "biological engineering"--putting together the known genes in the manner appropriate to achieve all the desired ends.

Meanwhile, work was going ahead on developing a suitable harvester. By 1961, the University of California, the University of Michigan and at least six private firms had constructed experimental machines, all of basically similar design.[36]

A look at the task to be accomplished sheds light on the mechanical principles that had to be incorporated in the machine. It also shows the need for a combined plant breeding and engineering approach. The vines had to be cut either at or below ground level. This was necessary to recover ripe fruit which fell as soon as the plant was touched. The need was for a fruit which would remain on the plant after it was ripe. But, a dirt separation problem arose immediately. Next the vines were lifted onto the machine and the fruit separated usually by some form of shaker. Here, ease of separation and a firm fruit were required. Finally, the separated fruit was carried on belts in front of sorters who discarded the underripe fruit. The sorted fruit was then elevated into bins or other receptacles on a trailer towed alongside.

One unforeseen problem arose when the earlier seasonal return of a large volume of organic matter resulted in unexpected buildups of thermophylic bacteria.

Harvesting by machine was found to cost some $5.41 to $7.47 less per ton than hand picking and used half the labor.[37] It is not surprising, therefore, that the rate of adoption of mechanical harvesters was rapid.

The social costs of adoption which had been largely neglected have recently been estimated by Seckler and Schmitz.[38] Even assuming that the displaced workers were paid their last level of wages in perpetuity, the investment in the research and development of the tomato harvester has paid off handsomely. But since compensation has not actually been paid to the displaced workers, it is not possible to conclude that all society is better off. In California we have added yet more field workers to the unemployment rolls and the urban slums.

The development and expansion of irrigation of new lands in California's San Joaquin Valley West Side provide a second example and illustrate the dangers of disregarding the economic repercussions of such a development on producers, both within and outside the region. When engineers and economists calculated the benefits and costs of constructing the California aqueduct and the dams and other canals needed to serve this region, their studies neglected to reflect price changes which might ensue in certain crops if the projected acreages on which the project income estimates were based were actually planted.

This approach is frequently taken when any long term forecasting is undertaken. Furthermore, the acreage of newly irrigated land, although considerable, seemed insignificant compared with the national total of 37 million acres of irrigated land in 1964. The West Side development has added approximately 70,000 acres to California's 1964 irrigated acreage of 7.6 million acres since that date and will add a further 330,000 acres between 1968 and 1990.[39] To appreciate the impact of this increase, however, one must examine more closely the potential crops for these new lands.

The price which the 13 irrigation districts in the region must pay for water depends on its source, location of delivery zone and pump-lift required. It varies from a relatively cheap $9 to $12 per acre foot in the north for water supplied from the Federal Central Valley Project to an expensive $20 to $40 per acre foot in the south for water from the State project. To demonstrate a capacity to pay these high water charges, feasibility studies assumed (1) that substantial acreages of high value crops would be grown, particularly nuts and deciduous fruits of which California is already the leading producer, and (2) that the prices of these crops would remain constant relative to other prices irrespective of the increases projected in their output.

Dean and King[40] projected California crop acreages to 1980 and 2000 which would be needed to supply demand at constant prices, assuming that crop yields, California market share, United States population and per capita income would continue their present trends. They found that the acreage need projected by this conventional method was less than that predicted by an analysis of recent acreage trends modified by judgments as to the effect of current and proposed irrigation projects. Thus, either the acreage of high value crops must be reduced or prices will decline. The price reductions which would result both under the original acreages projected in the feasibility studies and under more likely recent projections are not

insignificant. For most deciduous fruits, nuts, grapes and vegetables price declines are of the order of 5% to 10%, for spring potatoes 40% to 80%. The authors comment that:

> "Price declines of the order suggested would have several rather predictable impacts: (1) a revaluation of farm lands to lower levels; (2) requests for additional or stronger marketing orders, quantity controls or price and income supports; (3) requests for lower water prices; and (4) a less rapid expansion of irrigated cropland in the State."[41]

The disruptive effects of these developments on established producing areas are beginning to appear and are of great concern to all of agriculture in the State and particularly to those who finance production. This suggests that before any large scale irrigation project is undertaken, planners should estimate the cost of water at the farm headgate, any price changes which might result from the projected increase in acreage of various crops, the impact these changes will have on per acre earnings and the effect this would have on redistribution of income among producers in various producing regions. Use of constant prices masks the redistributive effect among producer groups of an increase in irrigated acreage.

The final example concerns the impact of technological change on environmental pollution, a topic currently receiving widespread attention. Pollution may be defined as the unfavorable alteration of our surroundings wholly or largely as a by-product of man's action.[42] It has been present as long as there is recorded civilization. What we are witnessing today, however, is a greater awareness of the problem as we observe a sharp increase in the physical destruction process itself.

The irrigation example can be extended to illustrate some of the external disadvantages which were not included as costs in the calculations. The dams, reservoirs and canals required in an irrigation project produce additional benefits such as flood control, boating and fishing. These are generally included in the benefit-cost analysis; for Corps of Engineers projects their existence must be demonstrated. On the other hand, the irreplaceable loss of scenic value and of natural wildlife refuges are not entered as costs. To some they are important. The proposed Upper Eel River development of the California Water Plan is being questioned on precisely these grounds.

To irrigate the new lands on the West Side, Sacramento River water has been diverted down the California aqueduct. The resultant reduction in downstream flow it is charged, has permitted salinity increases in the water below the take-off point to a level which threatens to disturb the delicate ecological balance over an extensive area of the river delta.

One problem which has plagued irrigation projects from time immemorial is the gradual build up of salinity in the soil. In the West Side region of the San Joaquin Valley this is compounded by the existence of concentrations of boron and salts in the soil which may well restrict cropping patterns and which received only cursory

attention in most of the feasibility studies. To permit sustained cropping, the soil must be leached and drained.

The present proposal envisages a master drain running most of the length of the San Joaquin Valley, which will enter the San Joaquin River near its confluence with the Sacramento River. The discharge of drainage water of relatively high salt content and containing fertilizer and pesticide residues will further lower water quality in the San Francisco Bay region. This has created wide public concern. The pollution from urban sewage disposal on the perimeter of the Bay is much more extensive, incidentally, both presently and in the projected future.

Pollution brought about by advances in technology applied to agriculture is easily seen in the effects of pesticide, herbicide and similar residues. There are two broad areas of concern. First, there is concern that chemicals which are toxic to some forms of life may remain in treated food crops; may be absorbed directly by humans as a result of spray drift, improper disposal or storage of containers; or may enter food chains and ultimately pose a threat to human health. The need for continued research and surveillance is evident. One problem in testing toxicity is that, for any chemical compound different species may have widely differing tolerance levels, none of which need be similar to human tolerance ranges.[43] Our present knowledge of the effects of many of the pesticides indicates a need for greater restriction on their use.[44]

The second area of concern is for the effect of these chemicals on harmless or beneficial species. The Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health proposes that the movement of pesticides between relevant components of the environment, air, water, organisms and soil be considered as part of a total system.[45] It also asks for more emphasis on developing disease resistant crops and on biological or integrated biological and chemical means of control. It notes that "(a) full cost-benefit appraisal of pesticides in the economy or in agriculture has not been made."[46] It is also quite critical of the testing procedures on which many of the regulations affecting use of materials are based.

Conclusion

In summary where any technological change is proposed there is need for what is popularly called a systems approach. The private and public benefits must be weighed against private and public costs, including hard to quantify effects such as pollution or substantial alteration of the environment. Obviously, the approach can be carried to extreme and judgment is required to keep the problem under investigation, discrete and manageable. Conglomeration cannot substitute for judgment.

In the development of agriculture in the United States we have seen that policies have been used to direct resources to desirable ends. At the same time we must recognize that many of the changes were brought about by uncontrolled outside influences. We have had policies which encouraged settlement of public lands and speeded discovery and adoption of yield increasing techniques. More recently we have adopted policies designed to stem agricultural surpluses, but these did little to curtain the rate of productivity increase. So far we have done almost nothing to either study or control external effects of the introduction of new technologies.

Perhaps for too long the technologist's principle of laissez innover has been in operation. We have assumed that new technology can extract us from the evils that it has unwittingly brought upon us. This view of technology as a self correcting system is naive. We must have a broader understanding of and more effective control over the effects of technology in the future if we are going to enjoy its potential benefits as we have in the past.

Footnotes

1. From 1870 = 20 to 1968 = 120, based on an index of 1957-9 = 100. U.S.D.A. - Economic Research Service. Economic Tables Jan. 1969. p. 1.

2. Schultz, T. W., The Allocation of Resources to Research, University of Chicago, Department of Economics, Agricultural Economics Paper 68:16, December 1968, p. 3.

3. Schmookler, J., Invention and Economic Growth, Cambridge, Massachusetts: Harvard University Press, 1966, Ch. 1.

4. Ruttan, V. W., Research on the Economics of Technological Change in American Agriculture, Journal of Farm Economies 42: 535-754, November 1960, pp. 749-50.

5. Durost, D. D. and G. T. Barton, Changing Sources of Farm Output, U.S.D.A. - ARS Production Research Report No. 36, pp. 14-19 and p. 52. February 1960.

6. Real estate index (based on the value of land and buildings) rose from 41 in 1870 to 93 in 1910 then levelled off (1947-9 = 100). Land in farms grew from 407 mil. acres in 1870 to 878 mil. in 1910, Loomis, R. A. and G. T. Barton, Productivity of Agriculture, United States 1870 - 1958, U.S.D.A. - ARS, Technical Bulletin No. 1238, April 1961, pp. 57-8.

7. Farm Labor index from 80 in 1870 to 143 in 1920; (1947-9 = 100). Peak labor force was 13.6 million in 1914 compared with 13.4 million in 1920. Loomis, R. A. and G. T. Barton, Productivity of Agriculture, United States 1870-1958, U.S.D.A. - ARS, Technical Bulletin No. 1238, April 1961, pp. 57-8.

8. From 8.8 million in 1870 to a peak of 26.7 million in 1918. U.S.D.A. - SRS, A Century of Agriculture in Charts and Tables, Agricultural Handbook No. 318, July 1966, p. 38.

9. 250,000 gasoline tractors in 1920, Cavert, W. L., The Technological Revolution in Agriculture 1910-55, Agricultural History, 30 January 1956.

10. U.S.D.A. - SRS, op. cit.

11. Christensen, R. P., W. E. Hendrix and R. D. Stevens, How the United States Improved its Agriculture, U.S.D.A. - ERS Foreign - 76, March 1964, p. 8.

12. Cavert, W. L., The Technological Revolution in Agriculture 1910-55, Agricultural History, 30 January 1956, p. 19.

13. Ibid., p. 19.

14. U.S.D.A. - Statistical Reporting Service, op. cit.

15. Durost and Barton, p. 17, op. cit. This accounted for 23% of the increase in farm output from 1940-1 to 1955. Since 1955 its influence has been negligible.

16. U.S.D.A. - Economic Research Service, Economic Tables, Jan. 1969, p. 15.

17. Responsible for 37% of the increase from 1939-41 to 1949-51; and 87% of the increase from 1949-51 to 1959-61. Christensen, et. al., op. cit., p. 8, or 43% of the increase from 1940-1 to 1955. Durost & Barton, op. cit., p. 17.

18. From 58 in 1934-6 to 123 in 1966-8 (1957-9 = 100). Economic Tables, op. cit., p. 4.

19. 55% of the increase between 1940-1 and 1955. Christensen, et. al., op. cit., p. 9.

20. Hybridcorn, 12% of the increase between 1940-1 and 1955. Ibid.

21. Change in composition - .84 index points per year 1940-1 to 1955, yield affecting practices (except weather) + .74 index points per year 1940-1 to 1955. Durost & Barton, op. cit., p. 48.

22. It would cause a reduction equal to 38% of the increase from 1940-1 to 1955. Christensen, et. al., op. cit., p. 9.

23. From less than 50 in 1935 to 175 in 1960 (1950 = 100) measured in 1947-9 dollars. Christensen, et. al., op. cit., pp. 13-14.

24. Dean, G. W. and H. O. Carter, Economies of Scale in California Cling Peach Production, California Agricultural Experiment Station Bulletin 793, February 1963.

25. U.S.D.A., Basic Statistics of the National Inventory of Soil and Water Conservation Needs, Statistical Bulletin 317, August 1962, p. 3.

26. Wittwer, S. H., Approaching Maximum Capacity in Production - Biological Limits of Productivity, Proceedings, 16th Annual Meeting, Agricultural Research Institute, October 1967, p. 100.

27. Loomis, R. S. and W. A. Williams, Maximum Crop Productivity, An Estimate, Crop Science 3: 67-72, 1963.

28. Wittwer, S. H., op. cit., pp. 107-115.

29. Wittwer, S. H., op. cit., pp. 115-120.

30. From 1959-61 to 1980, change in crop production per acre would account for 73% of the projected increase, increase in animal production for 40%. Christensen, et. al., op. cit., p. 8.

31. Fertilizer use, and to a lesser extent machinery use, vary in response to relative price changes. Loomis and Barton, op. cit., pp. 20-24.

32. See Griliches, Z., Hybrid Corn, an Exploration into the Economics of Technological Change, Econometrica 25: 501-522, October 1957, for an example of the rate of introduction of hybrid corn into each of the Great Plains States.

33. Comment by C. E. Kellogg on "urbanized farming" quoted in Partain, L. E., Rational Use of Land: Present, 1980 and Beyond, Proceedings, 16th Annual Meeting, Agricultural Research Institute, 1967, pp. 62-3.

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35. Johnston, W. E. and G. W. Dean, California Crop Trends: Yields, Acreages and Production Areas, California Agricultural Experiment Station Circular 551, November 1969, p. 98.

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38. Ibid.

39. Dean, G. W. and G. A. King, Projections of California Agriculture to 1980 and 2000: Potential Impact of San Joaquin Valley West Development, submitted for publication April 1970, p. 79.

40. Ibid., pp. 5-54.

41. Dean, G. W. and G. A. King, op. cit., p. 123.

42. President's Science Advisory Committee, Restoring the Quality of Our Environment, Report of the Environmental Pollution Panel, Washington, D. C., November 1965.

43. U. S. Department of Health, Education and Welfare, Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health, "The Mrak Report", Washington, D. C., 1969, pp. 249-50.

44. Ibid., pp. 7-19.

45. Ibid., pp. 174-6.

46. Ibid., p. 57.

MANAGEMENT OF SCIENCE AND TECHNOLOGY IN AGRICULTURAL DEVELOPMENT

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I would first of all like to thank Governor Forrest Anderson and the National Science Foundation and others for their support of this program. I am honored to be a member of the program, and I look forward to the opportunity of visiting with you concerning the adoption of science and technology into agriculture.

Our consulting organization has worked directly with a number of farmers and ranchers both in and out of Montana in aiding them directly in the adoption of new methods to their farm and ranch units. The agricultural economy has undergone significant changes in the last several decades, most of which can be directly or indirectly linked to the adoption of technology into agriculture.

Agriculture has enjoyed significant growth in terms of total output and increased productivity again primarily as a result of the adoption of new technology into the agricultural unit. Much of the technology which has been adopted has been made available to us through the efforts of the agricultural experiment stations around the country and particularly Montana State University here in Montana.

I am thoroughly convinced that we will continue to have a large quantity of new technology available for adoption into agriculture in the future. I suspect that you can find people who are willing to argue that there will be less technology available for adoption in the future than there has been in the past. I have also heard certain people argue that they expect technology to be adopted at slower rates in the future than it has been adopted in the past. I severely disagree with both of these positions in that I believe first of all that there will be large quantities of technology made available for adoption into agriculture in the future. I also sincerely believe that the tendency will be for this technology to be adopted at a much faster rate than it has been in the past. I say this primarily because of the hypothesis that the quality of the managerial input in the agricultural farm will increase significantly in the years ahead.

As an industry over the past several decades, we have seen a large out migration of labor from agriculture with an off-setting influx of capital into agriculture as an industry. Much of our new technology is labor-saving and nearly without exception it requires additional inputs of capital for its adoption.

During this same period of time the agricultural industry as a whole has been characterized by a relatively stable land base as an industry with sharp increases in the quantity and quality of management within agriculture.

As a result of these changes the individual farms within agriculture have shown a sharp increase in terms of size, either in terms of gross income or number of acres. The farms have also been characterized

by an increased volume of purchase inputs. Over the past few decades the farm business has increased significantly in terms of its complexity and with this increase and other changes has come an increase in the quality of the managerial input found on the average farm or ranch.

A significant part of the drive to adopt technology and increase efficiency within agriculture has come as a direct result of the severe economic conditions faced by agriculture resulting from the price-cost squeeze. The term "price-cost squeeze" as I am using it in this context simply means that there has been considerable pressure within the agricultural industry for cost of inputs going into agriculture increasing at a more rapid rate than prices received for agricultural commodities produced.

In my estimation many of these trends will continue as we continue to adopt technology at an even faster rate within the agricultural industry in the future. I feel there are tremendous opportunities for increased agricultural income to be generated within many individual farm units and within the state of Montana in the future. I feel that the correct use of technology is vital to our ability to generate this increased income. I also feel very strongly that the adoption of technology must be closely related and tied to the overall management of agricultural resources if it is to return the greatest amount of income per dollar expended. I think it can be said that in the past technology has been adopted into agriculture in individually isolated areas of activity, and I believe that one of the severe breakdowns in terms of our use of technology has been the failure to intergrate all of our technological advances in the most efficient way to use the individual unique resources on individual farm and ranch units.

The key to the potential increase for profits and output within the agricultural firm in the future is directly tied to the quality and ability of the managerial input within the individual farm or ranch unit. In my opinion management is now and is certainly going to continue to be the absolute key ingredient to success or failure in the agricultural economy within which we find ourselves. I think management is going to be much more important in the future than it has been in the past because of the complexity of the agricultural business and the necessity for this business to adjust to the changing economic environment within which it finds itself.

Management in many ways has been looked upon as a luxury that was provided if one could afford it on certain individual agricultural units in the past, but in my opinion it will be absolutely a must to success and/or survival in the future. Part of the job of management is to adopt the technology available in such areas as range management, plant science, soils, animal science, animal nutrition, mechanization, irrigation and other areas into a welded together profitable agricultural business. We recently worked with a client in Montana where it was determined that by increased utilization of known technology in range management alone that the total carrying capacity of an individual ranch could be nearly doubled by the adoption of such recommended range management practices.

This could be accomplished primarily because of the better utilization of the range resources through use of that resource in different time periods than the present pattern of use and a better distribution as a result of improved practices on the range itself.

There is considerable amount of research being conducted at the present time as to the economic feasibility of fertilization of range which according to some experiments can increase range carrying capacity two and three fold.

My friends in animal science are also talking about considerable technology in terms of continued improvement through careful selection of breeding animals related directly to the ability of offspring to perform in the production of beef. We have been working with a number of clients who are in the process of completely reexamining feeding programs and wintering breeding cows from what has traditionally been the pattern of such feeding with significant economic results. We are also working with at least one agricultural client who is using an extensive artificial insemination breeding program on irrigation pasture to significant advantage. Another important consideration on many ranches may be a consideration and examining the consequences of fall calving and other such practices. It certainly seems fair to say that there is a considerable amount of technology already available in the animal science, animal breeding, animal nutrition and associated fields to be put to profitable use on farms and ranches.

Our work with individual agricultural clients in Montana has clearly revealed that many acres of hay land now producing one and one half to two and one half tons of hay per year could easily produce four to five tons by the adoption of technology in the form of irrigation practices and fertilization programs and a host of related practices. There is a considerable amount of research now going on in relationship to double cropping on irrigation acres particularly in relationship to high moisture barley and other such crops. There are undoubtedly many acres of irrigated pasture throughout Montana which are now producing far less than their total potential because of the lack of management of these resources with the best technology available.

Another important area of the adoption of technology into agriculture is in the field of water management and/or irrigation. There are many farms and ranches which are doing an excellent job in terms of using the water resources to the best advantage. On the other hand there is a considerable abuse of water in many areas of Montana from extremes of both over irrigation and under irrigation resulting in severe impairment of the resources to produce at their maximum capacity. In many instances water is being so misused that two to three times the number of acres would be irrigated with the same water through the adoption of technology available to us in terms of irrigation systems. The misuse of water causes many problems including erosion, leaching and a host of associated problems. It certainly seems fair to say that the implementation of irrigation systems technology would be put to wider use to yield many profitable returns to individual farms and ranches and to the state of Montana through increased agricultural output.

It is also obvious that we have not begun to see the end of the mechanization of agriculture through the adoption of more complex forms of machinery within agriculture. This has, of course, been a fantastic change in the last several decades, and we will undoubtedly continue to apply our engineering expertise to problems of agriculture to generate increased quantities of machinery for adoption into agricultural units.

In conclusion I sincerely feel that much of the change that we have observed within agriculture in the past has been directly linked to the adoption of technology into agriculture. I further sincerely believe that we will continue to generate large quantities of technology in the future for adoption into agriculture. Also, according to my opinion, we will see new technology adopted into agriculture at an even faster rate in the future than we have seen in the past.

The true secret in my opinion to the profitability within the agricultural unit now and in the future is tied directly to the best use of technology which is directly the responsibility of management. I feel that our farms are going to become increasingly complex especially in terms of their requirements for larger quantities of operational management primarily again because of the necessity to absolutely adopt and utilize technology within agriculture. I think it is going to be absolutely necessary to demonstrate managerial skills to attract the kind of capital that will be required in the agricultural units of the future. This increase in capital flowing into agriculture on the individual farm units if nothing else is going to force the management input to become more and more sophisticated as we look to the future.

To me the technology revolution in agriculture is in no way over and it is possibly more fair to say that we are just well into it. Secondly, the input revolution is here and the key to survival is the way management reacts and uses technology available to it within the individual agricultural units. I feel that the major task of management is going to be to effectively intergrate the technology available from all of the various disciplinaries into an economic unit to effect the best utilization of the scarce resources on the individual farm and ranch units. I feel farm size is going to continue to increase with farm numbers continuing to decline. Likewise, I expect the ratio of capital to labor to continue to increase. I am very optimistic about the potential for increased profits within agriculture, and I sincerely feel that the presence of or lack of these profits is going to in large part depend directly upon the quality of the management input and its ability to use and manage the resources available to it on the individual farm and ranch units. Agriculture is now and will continue to be a vital and important ingredient to Montana's economy, and technology and its use within agriculture will continue to afford agriculture the opportunity to increase its productivity and income to the individual agricultural units and the state of Montana.

Note: Some lengthy discussion of a question and answer form followed which is not a part of the above paper. The above paper highlights the input of Mr. Rixe to the program through the formal remarks made and the discussion which followed as a key part of the total presentation.

POTENTIAL APPLICATION OF SCIENCE AND TECHNOLOGY IN AGRICULTURE

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Plant and Soil Science Aspect:

A. Water, Land and Plant Management:

This is an integrated system and, under irrigated conditions, one cannot generally discuss any one of these three areas independently. The requirement is efficiency of production per unit of water (and per dollar) used under irrigation. However, in some instances, the first two, water and land, can be discussed apart from plants. Irrigation water must be delivered to and through the land area in question. In Montana, this process consists, with only a few exceptions, of running water through a mass of leaky, weed-filled ditches. This is an extremely inefficient and costly process. The greatest cost is probably associated with the seep and saline (often alkaline) areas that develop, often on prime farmland, as a result of leaky ditches. The Clark Fork - Yellowstone valley area is a prime example. Other costs are those incurred in supervision of far too many ditches in an area, in maintenance such as weed control (with the associated possibility of pollution problems), in water loss because of the large surface for evaporation and probably others. Akin to this are the problems and costs associated with delivery of excess surface irrigation water back into drainage systems. The major cost here is from degradation of the water environment because of erosion and nutrient pollution. Again, there is more than one prime example of this in Montana.

Thus, a major potential is the application of social and engineering science and technology to the redesign (or design) of irrigation projects. This should consist of consolidation and construction of leak-proof ditch systems and erosion proof disposal systems. It should also consist of adequate surface and sub-surface drainage systems where necessary. Cost of such an application of technology would be great and would probably have to be assumed by society as a whole and not just by the farmers involved.

A major change should also be made in the irrigation process, the integrated water, land, plant system. This change should consist of irrigation with adequate, not excessive water, to supply plant and evaporative demands. For far too long we have irrigated our crops on some personal, individual basis such as the stage of the moon, the day of the week, or the actions of neighbors. These methods have something in common, they are all equally bad. Good methods for determining irrigation timing and quantity are available. The oldest method is the tensiometer, to date I have been unable to talk any farmer into using it. Methods based on soil and plant properties and micrometeorology that require computer calculations have been developed and are being used in other states. They are no better than tensiometers but because they require a computer, farmers tend to think they are.

B. Soil Fertility Management:

Fertilizer use in Montana has increased markedly in the last few years but, in the opinion of soil fertility experts, is only a small percentage of what it should be for greatest efficiency of production. Our native range is, in many areas, a dramatic example of lack of production due to low soil fertility. Data collected in the last few years has shown that dramatic increases in native range production can be obtained through use of high rates of nitrogen. Many other crops are under fertilized. It is probable that not more than 20% of the alfalfa fields of Montana have an adequate phosphorus fertility level. Perhaps 30% of the small grains are adequately fertilized. The technology of small grain fertilization in Montana is increasing rapidly; this is putting an increased demand on farmers in terms of sampling, testing and general knowledge.

C. Crops Management:

Climate and markets are built in restrictions on crop diversification of Montana farmers. However, within these restrictions many alternatives are available. Montana farmers (in fact, farmers everywhere) are often slow in looking for and adapting new opportunities with regard to crop management and there is good reason for this. All range of opportunities exist. Some examples are: 1) In many areas, summer fallow is completely unnecessary and, in fact, a waste of a valuable resource; 2) Many farmers continued to use inferior varieties; 3) In spite of problems with alfalfa weevel, acceptance of alternate crops such as sainfoin has been slow; 4) New (to Montana) crops are always a possiblity. Examples might be grass seed or cow-cockle; 5) Seed potatoes produce the highest return of any field crop grown in Montana, yet the acreage remains smaller than possible; 6) Montana should be looking toward the production of hybrid wheat and barley seed; 7) Excellent opportunities exist for increased forage production.

D. Land Management:

There are, of course, many possibilities for the application of science and technology to classical land management; i.e., tillage practices, erosion control, and etc. However, I use the term here with reference to how society uses the land--as agriculture, urban, recreation, transportation, water source and etc. I would argue strongly that very quickly there should be some mechanism where by society controls to some degree the use of land and directs that it be used for its best purpose. The rape of the best irrigated agricultural land in Montana by urban and transportation system development is a tragedy. If something is not done soon, Montana will lose a very large portion of its most stable and important economic base. Neither Montana or the world can afford this.

APPLICATION OF SCIENCE AND TECHNOLOGY TO ANIMAL PRODUCTION IN MONTANA

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Introduction:

Agriculture is Montana's leading industry, generating some 567 million dollars of cash receipts for Montana's farmer and ranchers each year. Livestock, on the average, accounts for about 53 percent of this figure, with income from the scale of cattle and calves dominating the picture (see Table I).[1]

TABLE I

Income From Livestock in Montana

Class of Livestock	Millions of Dollars
1. Cattle and calves	220
2. Milk	16 1/2
3. Sheep, lamb, wool	16
4. Hogs	11 1/2
5. Eggs	5 3/4
6. Horses	?

Today, with the problems of an ever increasing population and concern about the ability to produce adequate amounts of food, we often see statements to the effect that animals are inefficient food producers, they are wasteful or they are a luxury which only the rich nations can afford. For example, one such statement points out that if an acre of land produces 8,000 calories it will take 6,000 of these to keep livestock alive, leaving only 2,000 calories for human food.

This type of information fails to designate the kinds of acres referred to, or to point out that most of the feed requirements of livestock (the ruminant in particular) comes from acres which are not suited to crop production and if not utilized by grazing animals would have little or no value to mankind.

About 58 percent of the agricultural land in the United States is classified as grazing lands. There are about 800 million acres of such land in the 17 western states[2] and Montana has some 60 million acres of such land.

[1]Montana Agricultural Statistics - Vol. 12, 1968.

[2]A National Program of Research for Forage, Range and Pasture.

Roughage Production Efficiency

Within the context of "what is" and "what ought to be", I would like to suggest as my first point the need for improvement of the efficiency of roughage production. Roughages are of particular importance to the livestock industry as they provide some 3/4 of the feed intake of cattle and sheep and 2/3 of the feed intake of dairy cattle.

Our range reserach staff says that the application of present day technology could increase the productivity of our range lands 40 to 50 percent. This involves the adoption of such practices as delayed grazing, rotational grazing, control of plants unpalatable to cattle and/or sheep and grazing cattle and sheep together.

In addition to range land forages, forage crop production (harvested crops of alfalfa, grasses, etc.) has not progressed as rapidly during the last 10-15 years as have other crops, i.e. grain, etc.[1] In addition, harvesting and storage losses are still excessive amounting to 30 to 50 percent of the protein and 20 to 30 percent of the energy values of the plant.[1]

"What ought to be", then, is an effort to improve forage production both in amount and in quality; quality being defined in a broad sense as those factors that will bring about maximum beneficial response to livestock.

More dialogue between Animal and Plant and Soil people "ought to be". We have made a move in this direction by holding our annual Nutrition Conference and our Plant Food Conference "back to back", i.e. one following the other, with a common 1/2 to full days program designed to be of interest to both.

I have heard responsible people say the greatest thing we could do for Montana animal agriculture is improve range or forage production. In addition, if population pressures result in a demand for grains for human consumption that exceeds our ability to produce them, then livestock production from increasing amounts of forages will become more important. New technical developments, i.e. the use of non-protein nitrogen by the ruminant, will no doubt influence the composition desired in our roughages, i.e. put less importance on protein.

Reproduction Efficiency

The second point I would like to raise in the context of "what is", is the need for improvement of the reproduction of animals.

Animals, particularly the large animal, have a high maintenance requirement. They continue to eat whether they produce or reproduce. For example, 60 percent of the feed cost of lamb and wool production goes to maintain the ewes and rams. Increasing the number of lambs per ewe and ram

[1] A National Program of Research for Forage, Range and Pasture.

mating would significantly reduce production costs, yet no progress in this area has been achieved in the 1960s over the 1950s. Table II shows the reproduction efficiency of sheep from 1900 to 1969.

TABLE II

Reproduction Efficiency of Sheep	
1900	96 lamb/ewe
1958	98 lamb/ewe
1969	93 lamb/ewe

This is from a breed of animals where twinning has been common for years and where litters of eight per ewe have been raised and four lambs per ewe and two births a year are possible. Researchers say a 50 percent increase in lambs is feasible in the near future and a 300 percent increase is possible.

Reproduction in cattle is given as 80 percent with 90 percent an obtainable figure.[1] Actually, these figures mean little unless you know where they start from. A survey by our Veterinary Research Laboratory shows of the cows mated to a bull, 80 percent will conceive and be with calf at the time of pregnancy testing in the fall. However, of this number, 7 percent will abort and an additional 10 percent will die at birth or shortly thereafter. This leaves a 66 to 70 percent calf crop base on the number of cows mated to bulls.

Failure to breed is probably the one most common cause of dairy cattle leaving a herd and only 50 to 60 percent of the mares bred ever foal. So, "what ought to be" is a more widely adaptation of those things known to influence reproduction, i.e. better nutrition, better disease control, better general management. Elimination of the some 7 million cows that fail to calve could reduce the production cost of beef some 7 percent.

In addition, efforts of scientists to develop the technology of (a) twinning in cattle and (b) sex control would yield large dividends. Twinning in the beef industry could reduce broad cow numbers 6 to 8 million.[1]

Sex control, because steer are some 10 percent more efficient, would allow females to be restricted to replacement of brood cows and reduce production costs 2-1/2 percent.[1]

Sex control in chickens would allow the discontinuance of sexing and the destruction of 1/2 of the chicks hatched for egg production.[2]

Waste Disposal

The third point I would like to make is a need for improvement of waste disposal, particularly disposal where we have concentrated large

[1] A National Program of Research for Beef.

[2] A National Program of Research for Poultry.

numbers of animals in one place, as for example feedlots, dairy cattle, chicken and swine.

Waste is something we usually think of as throwing away. The problem is that there isn't any "away" anymore. What used to be away is now someone's back yard.

Range cattle return their waste to the soil-plant-animal system in an ideal fashion. Concentration of animals, however, overloads the available soil utilization system and creates pollution of soil, water and air.

The amount of waste is large as shown in Table III.

TABLE III

Relationship Between Food Production and Waste.

To Produce	Creates
1# milk	2# manure
1# vegetable	6# waste
1# chicken	8# manure
1# beef	25# manure

Technology to date has been confined largely to reducing cost of waste disposal (collection, storage and transportation to the land). Such things as hard surface lots, liquid manure storage, dehydration, lagoons, aerated ditches, etc., are examples.

Movement of large concentrations of livestock away from population centers may be a partial answer except we may run out of places to move. Pollution of air, water, etc., is just as objectionable to people in Three Forks as to people in Chicago or Denver.

It has been stated, waste is just a "resource out of place". Animal waste is a resource, i.e. as fertilizer and/or as a source of nutrients for other purposes (a feed supplement to animals) for example.

One researcher in this field contends animal waste is not filth but merely a fermented product. Man allows it to become filth by failure to harvest, store and utilize it properly.

A suggested manure harvesting-utilization scheme, harvested daily like milk or eggs, is shown on attached page.

Considerable technology of waste disposal, or utilization, is available. It is the economics that doesn't fit our present day concept of what is reasonable. What is reasonable, however, may boil down to a least cost situation, i.e. utilize it as a resource or pay to have it destroyed or disposed of in a manner acceptable to society.

In summary, I would like to leave with you four points.

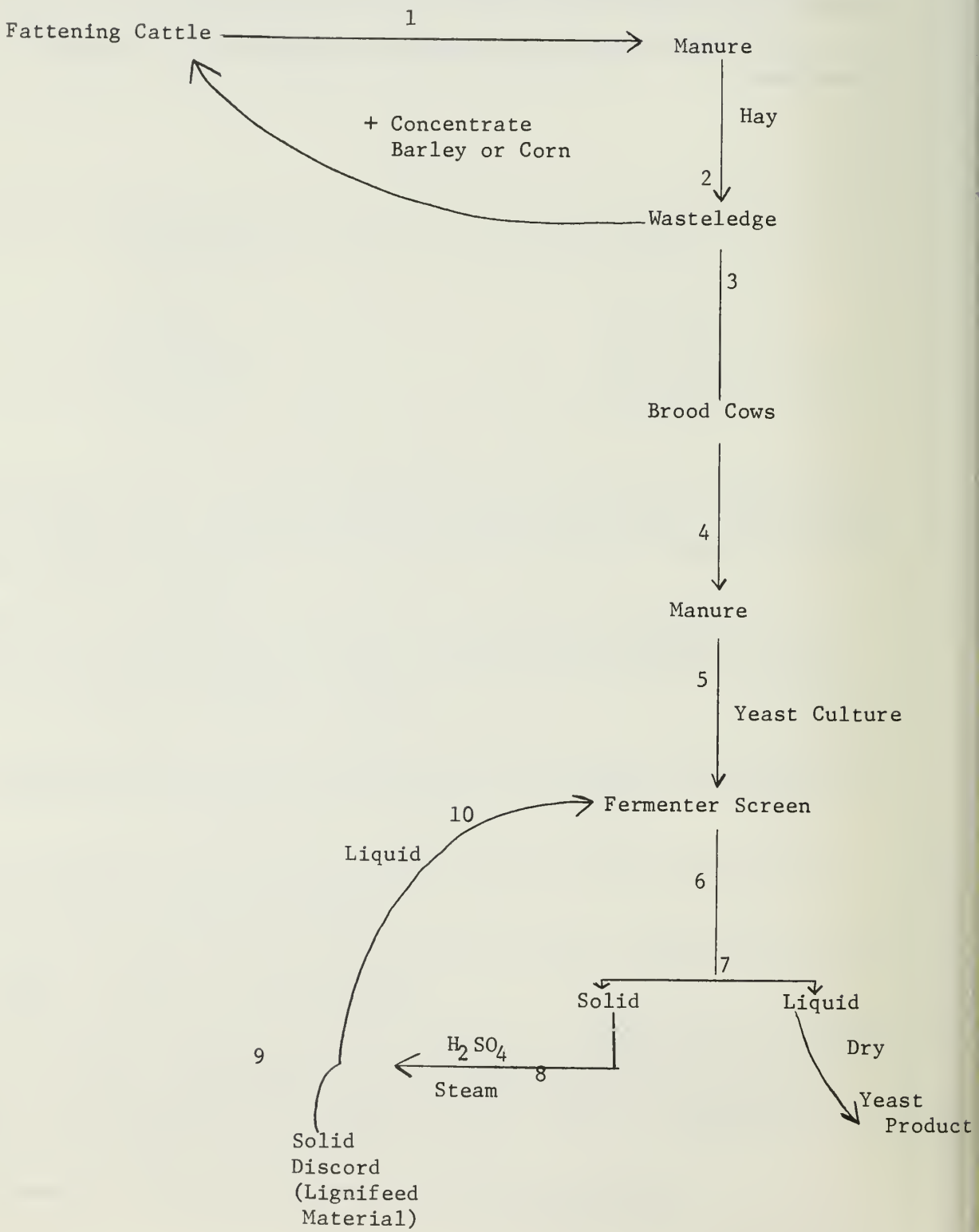
(1) Animals are an important source of food because, among other things, they utilize a land resource that cannot be used except by grazing animals.

(2) Improvement of range and harvested forage production, both in quantity and quality is needed.

(3) Reproduction efficiency of livestock has the potential for significant improvement.

(4) Animal waste utilization systems need to be more highly developed.

MANURE UTILIZATION SCHEME



SCIENCE AND TECHNOLOGY IN WATER MANAGEMENT

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Science and technology in the use of water for agriculture in Montana has surpassed the actual application or acceptance by farmers and ranchers. New methods of controlled irrigation have been developed, such as border diking and sprinkler irrigation. Shortages of labor have brought about the development of semi-automatic systems. All of these developments provided for more efficient use of water.

There are several reasons for the slow acceptance of the improved methods by the farmers and ranchers. Some are as follows: (1) finances, (2) lack of knowledge as to what can be done, (3) lack of information as to availability of water, and (4) lack of information regarding the laws governing the surface and subsurface water. To understand these limitations it is necessary to know and understand the history of Montana water and water law.

When Montana became a state, it was recognized that water belongs to the public and out of necessity it must be controlled by the legislative bodies of the state. The present system of water rights originated with the miners in California and brought to us by migration. The miners inch concept of measurement was introduced by these miners and is not a standard unit of measurement. It was adequate for the division of water, but it cannot be easily used by the layman to measure water used in agriculture, industry or recreation.

The laws governing our surface water are derived from customs, the court decisions of many cases, flavored by some legislative guides. Beneficial use of water is broad and general, ranging from agriculture and industry to the filling of swimming pools. Actual use is ever changing, first it was placer mining and dredging. With the depletion of easily washed gold, the water use was changed to industry and agriculture. Its use is now being changed to municiple uses and recreation.

The authority for the administration of Montana Surface Water Law is in the hands of the district court of each county. Water measurement and water use records are kept on those systems where a water commissioner serves the people. The records, in most cases, are not adequate to evaluate the actual water use. In most systems, measuring devices are inadequate, controls of water flows are antiquated and diversion structures scarce.

The efficiency of delivery and use in most cases are low. Parallel delivery canals through porous soils duplicate seepage losses. Seepage or low efficiencies of use are not bad because they do provide underground storage but it must be controlled. Because of the low efficiency of use in many areas, reuse of water is high and we cannot live without it. For example, if all the water from the West Gallatin River was put into a large container and distributed on the basis of the water rights it would require all of it, all of the time, with high efficiency of use, to fill the rights. However, the river is not completely depleted all the time and there is some run-off, the efficiency of delivery and use is not high. Therefore, reuse is evident and it is required to fill the

needs of the valley.

It is easy to look back at the past and it is easy to say what should have been done. But let us look at the future and lay a basis for all water use. The first step and possibly the most important is to provide one central agency with the authority to administer a sound, up-to-date program for all Montana water, both surface and ground water. This agency should be made up of at least four divisions: (1) Water Rights and Use Division, (2) Montana Water Laws Division, (3) Administration of Water Rights and Water Records Division, and (4) Water Education Division.

The Water Rights and Use Division should review and up-date the records of current water rights and all water used. This division must make recommendations for adjusting of water rights to meet the current changes. It must also bring about adjudication of streams not presently adjudicated. This action must be at state expense rather than by the current farmer or rancher action. This division must be a party to all water use studies.

The Montana Water Laws Division would maintain a current assembly of water laws and interpretations as handed down by the courts, making them available to all interested parties. They would assist in the formation of such laws required to properly manage Montana water. They would review all grievances where law is concerned and assist in bringing about a fair distribution of all water.

The administration of water rights and water use records division would keep accurate records of all water used within the boundaries of the State of Montana. They would have the authority to require water controls and measuring devices. They would standardize recording forms and units of measurement on a state-wide basis.

The fourth division would be for the purpose of education. It would be charged with the responsibility of dissemination of information on irrigation structures, irrigation management, efficiency of application, use of return flows, controlled irrigation and any other information necessary for more efficient use of Montana water. This division should be established at Montana State University, under the Agricultural Engineering Department, where the necessary personnel are available. The dissemination of information should be carried out under a much needed Extension Agricultural Engineering program.

The entire agency must be controlled by a commission, nonpolitical in nature. It must be composed of the following professional personnel: an Agricultural Economist, an Agricultural Engineer, an Agronomist, a Soil Scientist and a Judge.

Laws must be formulated to provide authority, definitions, or procedures of the following: beneficial use, abandonment of water rights, consolidation of systems, reduction of losses and many other areas necessary to make this agency function as a whole.

The writer recognizes the work being done by the Water Resources Board and the State Planning Board. He also recognizes the diversity and limitations under which these agencies now function. In order to have an integrated agency which could function smoothly and be responsible for all Montana water, changes must be made in the laws and the organizational structure.

INSTITUTIONAL ARRANGEMENTS IN AGRICULTURAL DEVELOPMENT

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Greater liberation from the constraints of the environment through science and technology offers new opportunities for human achievement but, at the same time, requires much more complex and adaptable institutional arrangements that add significant new dimensions to the age-old problems of social organiztion. By institutions, I mean the more or less formalized relationships among members of the community including the laws, regulations, customs and standard operating procedures.

A quotation from the book, The Public and Its Government, authored by Felix Frankfurter, characterizes the importance of institutional development. It reads, "Laws and institutions must go hand in hand with the progress of the human mind. As that becomes more developed, more enlightened, as new discoveries are made, new truths disclosed, and manners and opinions change with the change of circumstances, institutions must advance also, and keep pace with the times." Another from our own seminar leader, Dr. Roy Huffman, states, "The public has a major interest in the growth of institutions that contribute to the orderly process of society but have sufficient flexibility to permit desirable change." This is all to say that it is implicit in the scientific industrial system that it at once reduces man's dependence on nature and increases his dependence upon his fellow man. The primitive is an economy of nature, the industrial an economy of man!!

In many respects institutions appear to represent a drag on the economy. However, one should recognize that they represent the efforts of man to organize to achieve a large number of goals, not simply to get more material goods. It is also readily apparent that not all institutional developments are of a protective nature, i.e. the Sherman Anti-Trust Act, etc. In Agriculture we have been blessed with many highly productive social innovations that have given us the most scientific agriculture in the world. A classic example is the Morrill Act of 1862 that established our public education and research institutions throughout America. The benefits to our society from this Act alone are immeasurable.

Many of our social scientists believe that our present rate of technological change exceeds the optimum point. It is argued that the relationship between technological change in a society and the general good that accrues to the society is in the form of a curve--reaching a maximum at some intermediate rate of technological change and then decreasing. This curve is closely related to a society's capacity to deal with the "external effects" of technological change through institutional innovation and compensating public policies. I should point out that this is contrary to the view held by many physical scientists. They say the general good resulting from science and technology is positive, linear and steep. I would suggest that the many problems that we are experiencing today in the fields of urban development, pollution control, conservation and integration, to name only a few, are ample evidence that

the development of our institutional structure has not kept pace with that of science and technology.

To make the point more specific we might look at the problem of what could be termed, "the people left behind". The very nature of the process of scientific industrialization is to make existing job roles obsolete. Millions of people will continue to be affected by this problem in the United States, some through displacement from farming, but many more through displacement from other types of employment. The Committee on Rural Poverty pointed out that this remains one of the most perplexing problems of our political economy. Yet, we can find comfort in our sorrows. In the newly developing areas of the world the problem is overwhelming. With the newly developed technology in agriculture, now referred to as the "Green Revolution", tens of millions of people are threatened with technological displacement with little prospect of rapid and effective integration into the economy unless this problem of social organization is solved. We have considered technological displacement as a problem of individual adjustment for those who are displaced. The problem has been further accentuated by a host of obsolete institutions and organizational boundaries among our local government units. An example is the property tax as a major source of revenue for education and local government. It belongs to another era. Also, what kind of an institutional structure do you have with counties having declining populations of 2000 and less?

Let me turn to some specific illustrations of institutional problem areas that need attention if we are to utilize our scientific and technological developments in agriculture. I will list these first and then discuss each in some degree.

1. The 160 acre limitation
2. Beneficial use as a criterion in water right adjudication
3. Montana Water Code
4. Evaluation procedures
5. Federal-State-Local relationships in water development
6. Inter-basin transfer of water

Almost all of us would agree that the 160 acre limitation is long archaic and should be deleted as a requirement for irrigation development under the Bureau of Reclamation. Probably most of you know that Senator Murphy from California has introduced a bill to do this. The point is that this is an example of an institutional constraint to the economic use of our water resources that has hampered irrigation development.

I selected beneficial use as an example of an institutional criterion of our water code that has never really been put to the test. You may ask yourself the question, "What is beneficial use as it applies to irrigation?" Is it an irrigation efficiency of 15%, 45% or 70%? Is it the use of water for irrigation, power, recreation or some combination when these uses are competitive and water is scarce. Many more questions could be asked. Thus far our courts have not really had to concern themselves with this issue when water rights have been adjudicated. However, the time is fast approaching when these questions will become of paramount importance.

I cite our water code as an institution that many feel quite secure about. As you well know, we have the appropriation doctrine which states that, "First in time, first in right." This outwardly seems like a clear-cut situation. However, before you sit back in your armchairs too far, let me quote to you

from a recent study by Professor Stone, entitled, "The Long Count on Dempsey: No Final Decision in Water Right Adjudication". He states:

> "This last review brings up to date the chronicle of litigation on Dempsey Creek, a small stream of less than twenty miles in length: fourteen lawsuits with eight decisions by the Montana Supreme Court. In nearly every one of these lawsuits, all or substantially all of the people in the community of Dempsey Creek were litigants. There seems little risk in predicting that the past is but a prelude to continuing and endless litigation in the future.
>
> "Other watersheds in Montana have also had multiple adjudications. Those which haven't have been fortunate thus far. Periods of drought as well as increasing demands for water will give rise to new cases on new streams, with no final determination of the allocation of the waters.
>
> "This history of unending litigation among neighbors on a small watershed speaks for itself on the futility of Montana's present system of stream adjudication.
>
> "Dempsey Creek is a microcosm of Montana water law, not merely because of its contributions to the development of water rights doctrines: Dempsey Creek presents a portrait of the gap between the objectives of water rights settlement by adjudication and the practices which are generated by our statutes on adjudication.
>
> "Such legal development must be cold solace to the neighbors on Dempsey Creek, who would probably agree with this statement from one of their own cases:
>
> > Experience has shown that after the right of all of the parties taking water from a stream had been adjudicated, a subsequent appropriator would appear upon the scene, tap the stream and ruthlessly take the water, disregarding the decree rights and flaunting the orders of the commissioner appointed by the court to distribute the water according to the terms of the decree. The only remedy the prior appropriators had was to commence a suit against the new appropriator, the result being that of the rights of the stream had again to be adjudicated; and after that decree was entered, if another subsequent appropriator took the water the same process had to be gone over again. . . ."

This is a mute testimony to the fact that even our adjudicated water rights are not as secure as many might feel. An institutional change appears in order.

Our evaluation procedures that are used in the development of our water resources are again being reformulated. The Water Resources Council

has had a study group working on this problem for the past two years. Some of you may have appeared at one of the hearings that were held last year to solicit ideas and suggestions from the people in the field. It is my understanding that the Council will issue their guidelines within the near future. Some of the major issues that need to be resolved include: 1) the discount rate to use, 2) consideration of secondary benefits, 3) the use of non-market values, and 4) the time period for development. Though it is reasonable to say that much needs to be done relative to our evaluation procedures, I do believe the situation is greatly improved over what we had only a few years ago.

A number of institutional improvements are apparent in regard to Federal-State-Local relationships in water development. I think the Water Resources Commission offers an opportunity for the States to participate and make their wishes known to our Federal agencies. Certainly the Northwest River Basins Commission and the Governor's Council on Water Resources offer many opportunities to the Western States for cooperation and coordination in the development of our water resources and particularly as it relates to agriculture. At the state level the Water Resources Board is charged by the 1967 Water Resources Act to "coordinate development and use of the water resources of the State so as to effect full utilization, conservation, and protection of its water resources." Some question the ability the Water Resources Board has to enforce this charge over the other agencies involved in the development and utilization of our water resources, but it is probably too early to determine their effectiveness as of this date. We do know that many conflicts exist, but perhaps time will resolve most of these. At the local level the conservancy district legislation offers great promise if handled properly. Again, time is too short to make any predictions as to their effectiveness.

The question of inter-basin transfers is one that is receiving much attention, but is still in the formative stages. We all recognize the dangers that these proposals pose for Montana and its water resources. However, we must also recognize that they present unexplored development possibilities, ranging from the outright sale of water to storage, and to the development and use of water for agriculture and industry in our own State. The most ambitious of these proposals would tap the Canadian waters and transfer in excess of 100 million acre feet to all of the western United States, including Mexico as well as providing water for central Canada and the Great Lakes region. Its estimated cost is 100 billion dollars. It certainly behooves us to examine these proposals critically and develop the institutions needed if deemed desirable.

The rate of scientific and technological innovation could increase enormously in terms of agricultural development in Montana. A system for anticipating the negative effects of new science and technology is sorely needed. We cannot afford to wait for the problems to develop. The institutional innovations will have to be developed as joint products with science and technology if we are to reap the full benefits.

Let me close with a couple of poems which were published in Treasure Acres that were written by Dr. Kenneth Boulding. I think they exemplify well the fact that man can be the master of his own destiny on earth and that he is not a slave to environmental determinism.

A PRESERVATIONIST'S LAMENT

The world is finite, resources are scarce,
Things are bad and will be worse.
Coal is burned and gas exploded,
Forests cut and soils eroded.
Wells are dry and air's polluted,
Dust is blowing, trees uprooted,
Oil is going, Ores depleted,
Drains receive what is excreted.
Land is sinking, Seas are rising,
Man is far too enterprising.
Fire will rage with man to fan it,
Soon we'll have a plundered planet.
People breed like fertile rabbits,
People have disgusting habits.

Moral: The evolutionary plan went
astray by evolving man.

THE CONSERVATIONIST'S REPLY

Man's potential is quite terrific,
You can't go back to the Neolithic.
The cream is there for us to skim it,
Knowledge is power, and sky's the limit.
Every mouth has hands to feed it,
Food is found when people need it.
All we need is found in granite
Once we have the man to plan it.
Yeast and algae give us meat,
Soil is almost obsolete.
Man can grow to pastures greener
till all the earth is Pasadena.

Moral: Man's a nuisance; man's a
crackpot,
But only man can hit the
jackpot.

THE NEED FOR DISSEMINATION OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION TO PRODUCERS

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The panel members discussed a number of areas in which science and technology can contribute to greater agricultural output while minimizing the cost of resources used. The contribution of science and technology, applied to a market oriented economy within a framework of appropriate institutions, has been ably demonstrated.

However, it is equally important that this knowledge be widely disseminated among all agricultural producers and agriculturally oriented businesses. Without such widespread dissemination the potential benefits of science and technology will not be achieved.

This can be illustrated by an example of technological relationships which have been known for many years. This illustration is especially relevant for two reasons: (1) the technological relationships involved are not easily recognized through practical experience and must be learned by each new generation of agricultural producers, and (2) Montana is currently interested in developing a livestock feeding industry which must take into account many technological relationships if it is to compete effectively with other regions of the nation.

Observe in Table 1 that feed efficiency of steers diminishes as animal weight increases. Table 2 shows the same relationship with respect to feeding hogs.

Table 1. Amount of Feed Required for 100 Pounds of Gain on Steer Calves During Different Periods of Growth

Weight of Cattle	Feed Per 100 Pounds of Gain
Pounds	Pounds
501 - 600	682
601 - 700	916
701 - 800	1,038
801 - 900	1,235

Source: Feeding and Breeding Tests--Progress Report 1961-62, Oklahoma Experiment Station.

Table 2. Feed Consumption and Gain of Hogs After Weaning

Feed Consumed	Weight of Hog	Weight Added Per 100# Feed Fed
Pounds	Pounds	Pounds
0	35	
100	63	28
200	90	27
300	116	26
400	141	25
500	165	24
600	187	22
700	208	21
800	227	19
900	244	17
1,000	259	15

Many producers do not understand these relationships. As a matter of fact, some producers believe the reverse is true, i.e., that feed efficiency increases as animal weight increases.

The cost of not understanding these principles can be illustrated by the application of some elementary economic analysis. Table 3 shows the value added by successive increments of feed used. It is based on certain assumed prices of feed and hogs and utilizes a part of the data presented in Table 2. Notice that the fourth increment of feed adds only $1.59 to returns. The fourth increment does not pay for itself. If a farmer feeds this fourth unit of feed he foregoes the more profitable opportunity of using it for feeding lighter weight hogs or selling it for cash. Society as a whole looses some of the benefit of this fourth increment of feed which could be used to greater advantage in other uses. Thus it is apparent that not only does the farmer loose potential profits by ignoring or not understanding these relationships but society also looses potential economic returns.

Table 3. Value Added by Each Unit of Feed

Increment	Cost of Each Cwt. of Feed Consumed @ $2.50/cwt.	Weight of Hog	Hog Price Per Pound	Total Value Per Hog	Value Added by Each Cwt. of Feed
	Dollars	Pounds	Dollars	Dollars	Dollars
		165	.160	26.40	
1st cwt.	2.50	187	.160	29.92	3.52
2nd cwt.	2.50	208	.165	34.32	4.40
3rd cwt.	2.50	227	.165	37.45	3.13
4th cwt.	2.50	244	.160	39.04	1.59
5th cwt.	2.50	259	.160	41.40	2.36

Similar examples can be drawn from other scientific disciplines affecting agriculture. It is becoming increasingly important that agricultural producers understand these technological relationships because competition among farmers and between regions is increasing. The result is narrower profit margins for individual producers. With the narrow profit margins that exist today, it is virtually impossible for producers to stay in business unless agricultural inputs are employed in their most profitable amount and combinations.

Wide dissemination of information and analytical methods will be even more critical in the future. Those producers who adopt new and profitable technology put increasing pressure on other producers to become as efficient as possible.

PROBLEMS AND OPPORTUNITIES IN WESTERN MONTANA'S OVERSTOCKED TREE STANDS

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Western Montana has an excess of overstocked stands of sapling or pole-sized trees. These stands are not satisfactory from the standpoint of many uses and values of the forest. Their treatment to improve usefulness and productiveness of lands occupied presents problems of economic as well as environmental nature. They also provide opportunities for needed raw materials and for improving many values.

Before going further it seems well to clarify what we are talking about as overstocked stands. These have 1,500 to 40,000 trees per acre, but 300 to 600 would probably fully utilize these sites. Most are even-aged and of small diameter. Some are relatively young and some quite old. Many occur on lands that are normally highly productive from a timber growing standpoint.

The prevalence of this condition is illustrated by the findings of a survey of lodgepole pine stands in the Clark Fork Unit which showed one-third of the type to be in stagnated stands (Hutchison and Roe, 1962). These stands cannot recover from this serious suppression. Of this one-third, 86 percent is in large and small pole-sized trees (10.9 to 5.0 inches in diameter, breast high); the remainder is in seedlings and saplings. Even in the two-thirds of the type not classified as stagnated there are many stands with too many trees and depression of diameter growth.

Most other species in western Montana--larch, Douglas-fir, ponderosa pine, spruce, and grand fir--also frequently occur in extensive overstocked stands. Some stands are heavily infested with mistletoe, as well as being seriously overstocked or stagnated.

Most of these overstocked stands came about as a result of extensive wildfires that played a prominent role in molding western Montana's present environment. As a result, most stands are fairly large and continuous. Some overstocked stands have come about following logging, but these usually occupy tracts of far smaller size than those resulting from wildfire.

Effects of Overstocking on Timber Values

On forest lands classified as suitable and available for production of industrial wood, one concern we have is overstocking and how it affects

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Hutchison, S. Blair, and Arthur L. Roe. Management for commercial timber, Clark Fork Unit, Montana. USDA Forest Serv. Res. Pap. INT-65, 32 p. Intermountain Forest and Range Exp. Sta., Ogden, Utah. 1962.

wood production capability. Hutchison and Roe (1962), speaking of timber production on the Clark Fork Unit, stated: "Overstocking is, in fact, the most important single roadblock in the way of higher production." This statement applies equally well in other portions of western Montana.

Overstocking, particularly when severe during the critical younger years of the stand, results in excessive competition between trees for light and moisture. Diameter growth is sharply reduced, and, if overstocking persists long enough, the surviving individual trees cannot recover from the effects of suppression and the stand becomes stagnant.

The problem of too many trees in stands is most severe with lodgepole. Unless it grows rapidly during the first 40 years of its life, it will still be small at 80 to 100 years when the stands are mature. The problem is only slightly less severe in the larch type.

Where these overstocked stands are heavily infested with mistletoe--as frequently occurs--there is a sharp reduction in height as well as diameter growth.

Stands that fall behind in growth never catch up, with the result that overstocking requires lengthening rotations or harvesting of smaller trees. Some stands are so overcrowded that they will produce little or no wood suitable for lumber or solid wood products.

Older stands, where some of the trees have asserted dominance and are of good sawtimber size, generally retain a large amount of suppressed, dead standing, or dead-and-down material that contibutes to the mass of wood residue left after harvesting the larger size classes. Unless uses can be found for it, this mass of woods residue must be disposed of in a costly manner.

Obviously, we pay a high price for overstocking. Potentially highly productive soils are not producing timber nearly as fully as they are capable of. Stagnated stands grow little--if at all, and the other overstocked stands grow more slowly than they could and should.

Effects of Overstocking on Other Values of the Forest

Forests of western Montana have many uses and values. Most of these forest lands are federally owned and, as such, will be managed under the multiple use principle. Thus, the effects of overstocked stands on wildlife habitat, watershed, recreation, esthetic values, and protection hazards also must be considered. Specific information is generally lacking, but experience and judgment indicate adverse effects on many of these values.

Value of the extensive areas of overstocked stands as wildlife habitat, at least for big game, is generally low. Production of herbaceous species and browse, shown to be inversely related to crown cover (Jameson, 1967),

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Jameson, Donald A. The relationship of tree overstory and herbaceous understory vegetation. J. Range Manage. 20(4): 247-249. 1967.

is meager. Patches of thickets or overly dense stands have, however, been claimed to be essential for elk cover. The relative values for upland birds and other wildlife species are less well known, but it seems reasonable to assume that the value of stagnated stands would be extremely low because of scarcity of vegetative or insect foods.

Value as watershed may be excellent, if the principal concern is protection against erosion and floods. But it may be poor if the concern is for water yield.

Recreational value would seem to be extremely low, unless an individual literally wants to get away from it all, and it wouldn't take very many acres of stagnated stands to furnish complete seclusion for quite a number of people. Such stands have almost no value for hunting, hiking, or sightseeing.

Esthetically, stagnated and overstocked stands provide a pleasing green forest when viewed from a distance. But extensive areas may become monotonous and uninteresting, and the understory flora and the fauna are not very rich.

The hazard of wildfire starting in these overstocked stands should certainly not be any greater than in a normally stocked forest. But once the fire starts, if fuels are dry, a crown fire of extensive nature is almost assured. Control would be difficult.

It appears that an orderly replacement of overstocked stands would be desirable if the application of such a measure did not cause long-lived damage to timber and other values.

Projections of Timber Supply and Demand Indicate Shortages

Projections of future softwood timber demands, both in the years immediately ahead and long range, indicate serious shortages. At the moment, with lumber markets as they are, this projection seems quite unreal. But if other obstacles to housing starts are overcome, demand probably will accelerate sharply. In 1968, when 1.9 million new houses were built--including mobile homes, there was a shortage of available timber to support the forest products industry in the western United States.

There is a critical housing shortage in the United States. It has been estimated that 26 million new housing units are needed in the next decade, an average of 2.6 million new homes per year.

The President's Task Force on Softwood Lumber and Plywood, in examining supply-demand pressures to meet these housing goals, concluded that demand for softwood timber would build up sharply after 1971, and that the supply situation could become acute by 1974. As a result, there would be a strong upward pressure on prices of softwood lumber and plywood. A prompt start on an accelerated forestry program could lessen this pressure--but not eliminate it.

Concerning the long-range projection, they concluded that "if prudent steps are taken to increase timber supply from all sources, as well as to improve the availability of substitutes, the supply-demand gap can be closed, while fully preserving the quality of the environment."

The Forest Service report on "Possibilities for Meeting Future Demands for Softwood Timber in the United States," in 1969, indicated that to forestall shortages and very large price increases for the items by 1990, and beyond that date, intensified and large scale management of public and private forests will be needed soon.

More Intensive Management for Timber Production Is Needed

These predictions of future demands emphasize the need to get all forests, suitable and available for the production of industrial wood, into a fully productive condition. If we don't solve the problems of overstocked stands, which make up such a large portion of western Montana's forests, we will be locking ourselves out of many forest areas we have assumed would be a part of the timber-growing base.

These stands--particularly those on the better producing sites--need more intensive management. Some will require thinning to accelerate growth on the remaining stems and shorten the rotation. Some--because of age, species, or severity of overstocking--will not respond; and the existing stagnated stands will need to be converted to young vigorously growing stands by cutting and regeneration.

It seems possible that if this work is done with full consideration and design for other values (as emphasized by the President's Task Force) then those other values could also be enhanced.

There Is Considerable Wood in the Pole-Sized Stands

These overstocked stands contain an appreciable amount of wood that could contribute to needed timber supplies in the near distant future. Poletimber represents in Montana about one-third of the total cubic volume of trees 5 inches and larger. Statistics are not available to show how much of this is in overstocked stands, but it is unquestionably quite a high proportion.

Ability to utilize pole-sized material would provide added incentive to achieve the more intensive management that is urgently needed. If use of these small trees could be made profitable, it would also contribute to jobs and local and state economy.

There are some who will question whether increases are needed in timber production to meet future demands. Their thesis is apparently based on two assumptions: first, prices for wood and wood products will rise to the point that substitutes will substantially replace wood; or second, that the growing of wood on many commercial forest lands is actually marginal or unprofitable.

These assumptions seem to revolve largely around the present U.S. position in the world community that includes a few well-developed nations enjoying a high standard of living and a large number of underdeveloped nations. The United States is one of the well-developed nations, and with only 6 percent of world population it is said to use 60 percent of world resources. Whether it is 60 or 40--or even less--could be debated with vigor; but, clearly, the per capita consumption is many times that of most other parts of the world. This means that we are obtaining a large part of the resources we enjoy at the expense of other nations.

Extrapolation of existing price relations generally are based on the assumption that we will continue to enjoy the same share of world resources, that there will be no barriers to our continuing to obtain resources from elsewhere, and, hopefully, that we might achieve zero population growth. These assumptions seem to me to lack realism and have inherent moral defects.

I would like to assume that there will be eternal peace and there will be no barriers to the availability of resources. But harsh realism tells me that man has not yet become domesticated--and we should suffer no such delusions.

I would also like to assume that uniformly across the world, we can achieve--fairly soon--a zero population growth. But this, too, seems unlikely. Even if achieved in the foreseeable future on a total worldwide basis, it seems unlikely that growth of the different nations will be balanced, and well-developed nations like the U.S. will make up an even smaller proportion than we do now.

I would also like to assume that we are going to be good neighbors in the world community and share equally with our fellow nations the resources of the world. But this will likely be a bitter pill. If we are sincere in our support for substantial improvement in the standard of living by the, now, underdeveloped nations and they increase their consumption, this will require a reduction in our consumption of certain nonrenewable resources.

If we sanctimoniously profess our support for improvement in underdeveloped nations, but cling to our present level of material needs and use our affluence to compete on the world market, we will have to pay more, they will have to pay more, and the entire array of relative prices for wood and substitutes could be reshuffled in a major way.

There seems to be reasonable doubts that assumptions regarding relative prices for wood and products derived from wood, as compared to substitutes, are reliable for many decades in the future.

Thus, it would seem that the most prudent course to follow is to assure that our forests are brought up to and kept in a highly productive condition, and that we work toward developing more adequate supplies as a hedge.

Whatever we do must be done within constraints of safeguarding essential features of environmental quality.

Problems Accompany the Opportunities

These overstocked stands present opportunities to produce more wood for future markets--but they also offer problems. Anyone who is either overly optimistic or overly pessimistic is jumping to conclusions. At this stage, there is still much that we don't know. It is necessary for us to take a careful look at ways of improving the technology for utilizing small trees and wood residues now left behind. We really haven't faced up to the matter of efficient use of such material.

Whether we can turn the wood in these overstocked forests into an asset and utilize this material as a manipulative technique to get forests into good condition for timber growing, and protect or improve the forest for other values, is dependent on many factors relating to sapling and pole-sized trees and stands.

For example, small logs or trees are generally more costly to harvest, handle, and use. Improvement in efficiency of harvesting, transporting, and manufacturing small logs or trees is essential. Several speakers more knowledgeable in this subject will talk about this today--so I will leave it to them.

Availability of markets for products that can be made from the small-size trees is an extremely important factor. The market obviously does not favor small timber. Most of the products that can be made from small timber can be made from larger trees, and the smaller timber has not been competitive where both are available. The only products for which small-size stems have an intrinsic advantage are some of the roundwood products and posts and poles. Neither of these have too promising an outlook for greatly expanded demand.

This is a rather dismal outlook for pole-sized and smaller material. But we must not forget that if the Nation's total resource position changes materially, this material may find ready market for certain sawn products, roundwood pulpwood, chipboard, particle board, and other products. Greatly improved efficiency in the harvesting, transporting, and manufacturing will aid materially in the utilization of such material.

A vital problem will be the ability to harvest this small-size timber and transport the material to utilization plants, with full consideration for other uses and values of the forests in which they occur. With species and within stands that respond to thinning, the principal concern will be construction of roads or use of other means for transporting the material and the compatibility of such utilization with esthetics, watershed protection, and fuel reduction. These problems certainly are not insurmountable. Thinning can have some value for wildlife habitat (McConnell and Smith, 1965) and may for other uses.

McConnell, Burt R., and Justin G. Smith. Understory response three years after thinning pine. J. Range Manage. 18(3):129-132. 1965.

Where the stands are stagnated and the individual trees won't respond to release, the only alternative is to completely harvest and start over with a new stand. The same may be true where the stand is heavily infested with mistletoe--until some means is devised for cleaning up existing infections. In addition, it would seem possible to design sizes and shapes of patch cuts so that esthetic, wildlife habitat, and watershed protection values were not only protected but enhanced.

As I have already said, economic feasibility of utilization of these pole-sized trees is an overriding consideration. Small-diameter logs are generally more costly to harvest, transport, and use. For the most part, they return the same--or less--products than if made from the same volume of larger timber.

On the other hand, it is going to be very important when we evaluate the opportunities that we do more than compare the market value of the wood with costs of harvesting and manufacturing it. There are several other considerations of importance that need to be brought into the calculations.

Where present utilization standards provide the basis for comparison we need to consider the nuisance value of residue left from thinnings, and the nuisance value of the residue left from harvesting older stands. Disposal by burning will involve cost of burning plus the possibility of air pollution. If we don't burn, the residue may interfere with subsequent management, and may create exceedingly high fire hazard. Also, it will materially impair esthetics.

The value of creating a fully productive forest and assuring adequate supplies and continued use of wood in the future should be considered. As pointed out earlier, there is absolutely no assurance that we will not need the levels of production now being projected 10 to 60 years in the future. International conflict and competition in the world marketplace may change quite radically the availability of wood and substitutes, and influence the relative price structure.

Also we must consider that fire danger can be reduced by removing fuels from the ground and by breaking up the continuity of stands and fuels. Furthermore, there are the improvements in wildlife habitat, esthetics, recreation, and watershed to be considered.

The problems of small trees and wood residues have been with us a long time--and they won't be easy to solve. The issues are compounded now. Formerly, it was primarily a matter of market economics. Now, environmental considerations are paramount in some places and extremely important everywhere. They may more than offset the traditional cost constraints that have held back more complete utilization of western Montana's small timber.

APPLICATIONS OF LOGGING COST RESEARCH

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I think most of you would agree that to be an expert in any field today requires a lot of work and study, and a little help. Now to help you to be better informed about some of the terms I will use today that you may not be familiar with, I am going to hand out our "One-upmanship Guide." You will find this a handy gadget for helping to find the origin of certain terms, as well as giving you the ability to generate some sophisticated terminology of your own. We actually borrowed this idea from our friends in the aerospace field where a new term, word, or phrase is born every day. We have had a lot of fun with it, and maybe you will too. An explanation of how to use the guide is attached--for example, just pick any three-digit set of numbers such as 7-8-6, and you have coined an expression for an impressive-sounding, third generation (at least) logging device called the Digitized Third-Generation Harvester.

One-Upmanship Guide

(The Loggers Buzzphrase Generator)

One source of embarrassment to a logger or manager can be the continuous stream of new terms used to describe the latest equipment and methods in our growing technology. To relieve the harassed logger, the "buzzphrase generator" has been prepared. This could give him the ability to be an instant expert in the state-of-the-logging-art, or at least make his peers think so.

The generator consists of three columns of buzz-words numbered zero to nine:

....think of any three-digit number and then select the corresponding buzz-word from each column and, suddenly, you really sound good. Rip off a few in quick succession and you begin to tower. Even if the meaning is wrong, the ring of the phrase makes even the most expert logger stop before he questions it.

0. Systematized	0. Split-Torqued	0. BARKER-CHIPPER
1. Roll-Jointed	1. Belt-Shifting	1. SKYCRANE
2. Hydraulic-Looped	2. Winch-Ripping	2. JAMMER
3. Synchronized	3. Power-Shifting	3. DOZER
4. Optimal-Monitored	4. Gearmatic	4. FELLER-BUNCHER
5. Parallel-Functioned	5. Oil-Clutched	5. LOADER
6. Total-Balanced	6. Chokerless	6. HARVESTER
7. Digitized	7. High-Leading	7. YARDER
8. Transitional	8. Third-Generation	8. STACKER
9. Time-Phrased	9. Haulbacking	9. SKIDDER

Before I get down to the business of talking about logging systems and cost, I would like to touch briefly on a subject that has become much more important in all of our thinking and actions in the past year or so--environmental quality. There really isn't anything new about this phenomena, but only the important place it now occupies in the minds of our citizens, and I think rightly so, with the exception of the most radical of what we might call preservationists. I mention this because it most certainly will have a decided impact on the way we will be doing business in the future and, of course, will affect the cost of doing business to varying degrees.

I will have to confess, however, that I am one of those who firmly believes that the solution to our problem lies mainly in a renewed resolve to put into practice what we already know about logging to minimize the impact on the environment. In almost 20 years association with road and highway construction, logging, and related activities, I have observed people and institutions doing what comes naturally--the minimum needed to get by. In other words, I believe a change in attitude will contribute greatly to solving the problem in many instances, with only minor additional cost. Careful planning and execution of road and logging plans will produce operations that will lay much lighter on the land.

With these comments, I would like to mention now just a few other items that add cost to logging. They are: smaller size timber in more remote locations, high accident rates, and expensive new equipment.

What can be done to lower costs, considering all of the problems just discussed? We hope research can help, and the Forest Engineering project was instituted at Bozeman in 1961 for the purpose of applying engineering techniques to logging and other forest management problems.

This is a new activity of the U. S. Forest Service. The laboratory is part of the Intermountain Forest and Range Experiment Station with headquarters in Ogden, Utah, and is one of five located across the country.

Our approach to the logging systems studies has been divided into four phases, as follows:

Phase I. Understanding Present Logging Subsystems.

- o determining best ways to gather information
- o analyze present logging operations through data gathered.

Past studies of logging operations in the Rocky Mountain area and the West in general have been few and far between. The data that had been collected was mostly in the form of logging costs applied to a very large area, with no detailed information that could be used to analyze the variables that influence cost. Our first studies of log-making (felling, limbing, bucking) and crawler tractor skidding were made using standard stopwatch methods and a time-lapse camera. Data-gathering methods were evaluated in the early studies and the results are reported in a publication titled "Efficiency of Three Data-Gathering Methods for Study of Log-Making Activities," by Rulon B. Gardner and Paul L. Schillings (Intermountain Forest and Range Exp. Sta. Research Note INT-100, 1969).

Our first analysis of a subsystem was a comparison of crawler tractor skidding methods, to be discussed later.

Phase II. Determine Best Present Logging Systems.

- o apply Operations Research techniques
- o fill gaps with controlled experiments.

Later studies of skidding and yarding operations that included rubber-tired skidders, Idaho jammers, high-lead and shovel logging made it possible for us to optimize skidding, using the equipment types observed. The results of these studies will also be discussed later.

Phase III. Design or Redesign Best New Systems to Meet Future Needs.

- o consider future logging expansion
- o coordinate with equipment manufacturers.

We are just now nearing the completion of Phase II and should be working actively in Phase III within the next year or two.

Phase IV. Continuously Update Systems in Use.

- o recycle through phases
- o reapply Operations Research techniques.

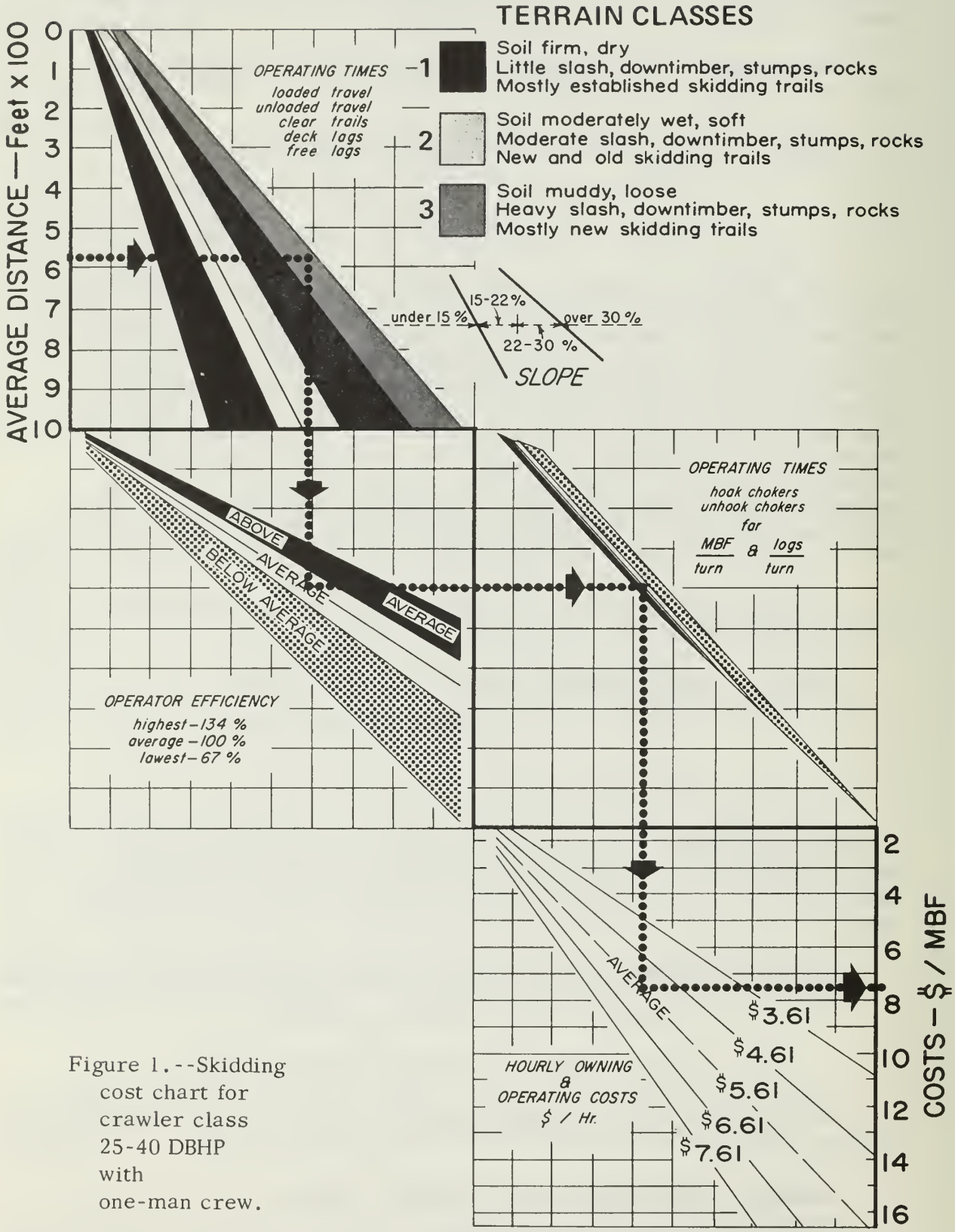

Figure 1.--Skidding cost chart for crawler class 25-40 DBHP with one-man crew.

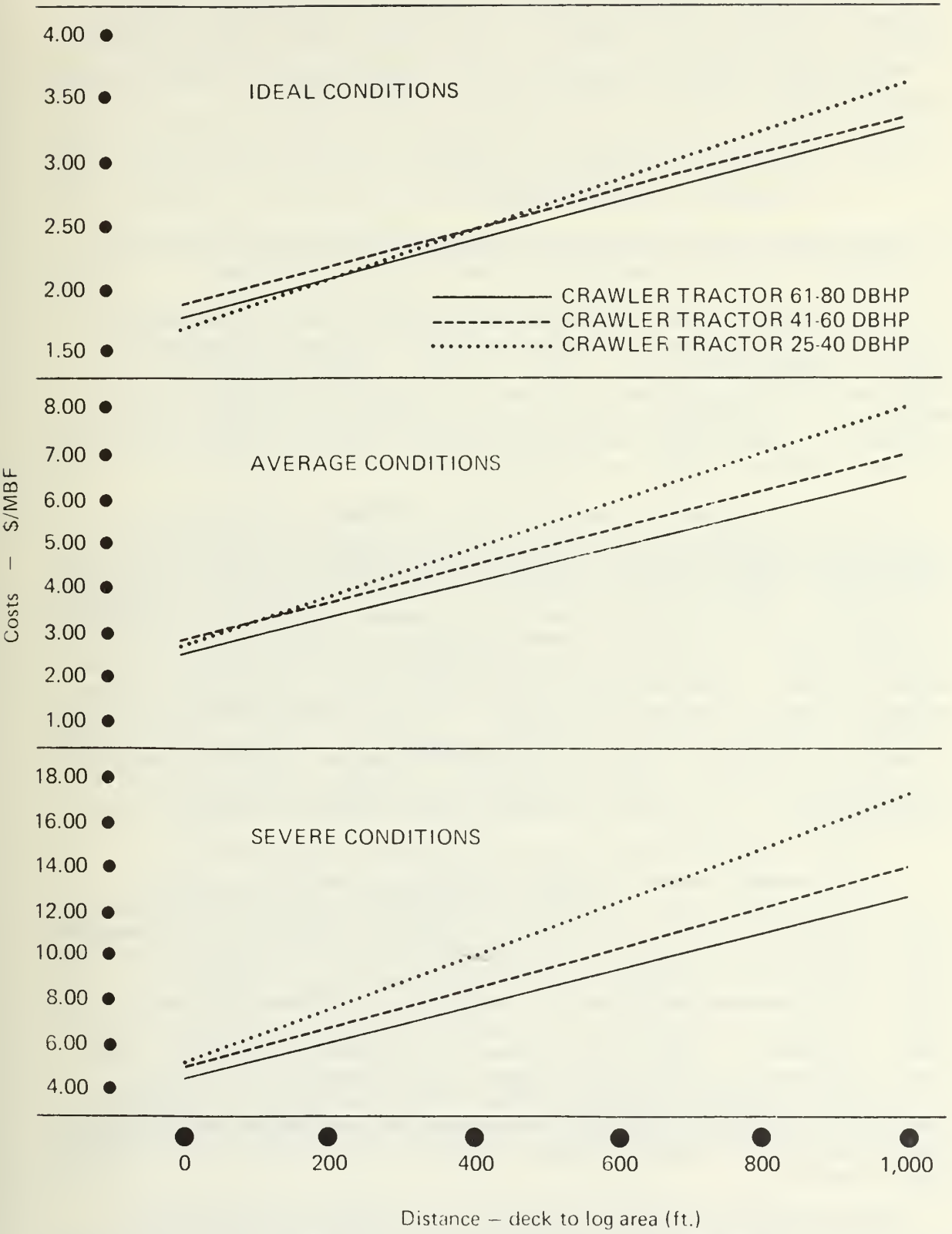

Figure 2.--Skidding costs under three defined operating conditions with one-man crew.

Phase IV is a continuing job where we keep up-to-date on any new equipment or methods to determine how and where it fits into the system.

What are the expected results of our logging research? Simply stated, they are:

- economic and industrial growth
- improved forest management.

Admittedly, these are very broad "motherhood" type objectives, but nevertheless, they are descriptive of our overall objectives.

Now I would like to talk about the results of some of our studies and how they can be used by loggers and those who are responsible for planning logging operations. All of our data, except for some of the high-lead or skyline systems data, was collected in the Northern Rocky Mountain area--principally western Montana and northern Idaho. Some of the data for rubber-tired skidders was taken in Wyoming, and on the skyline systems in eastern Oregon and Washington.

I will talk about the results of our first study of crawler tractor skidding and then the later expansion of that study to include other skidding and yarding methods. Three of the most popular sizes of tractors were studied initially--25-40, 41-60, and 61-80 DBHP (draw bar horsepower). A relatively simple parametric analysis procedure was employed to study the major variables that were known to influence skidding production and therefore cost. The variables used in this study were skidding distance, terrain classes (three were used that could be easily identified on the ground), slope, and operator efficiency. After a test of the significance of these variables had been completed, a regression equation was developed to predict production. When this was done, a method had to be developed to present the findings in a form useful to loggers. We felt that a nomograph would be the easiest method to use, as shown in figure 1 for a 25-40 DBHP class tractor.

In the example shown, skidding distance was 580 feet, terrain class 3, slope 28%, and an operator of average efficiency. The resulting cost for skidding is seen to be about $7.50/MBF (1,000 board foot measure). Complete results of this study are reported in our publication, "Selecting Crawler Skidders by Comparing Relative Operating Costs," by Paul L. Schillings (Intermountain Forest and Range Exp. Sta. Research Paper INT-59, 1969). A number of trade-off charts were constructed for this data, as shown in figure 2. These charts appear in this same publication. Note that using one-man crews (operator sets his own chokers), the larger tractor is always more economical under severe conditions. Using these nomographs and charts, a logger can optimize his operations using crawler tractor skidding by computing logging costs for the conditions he must operate under.

Now lets turn to a later publication that presents a method for optimizing skidding or yarding comparing nine different methods. In this later study, we expanded our coverage of skidding methods, as mentioned earlier, to include rubber-tired skidders, high-lead, Idaho jammer, and shovel skidding and/or yarding. In our extended studies, we found by using a backward elimination analysis of variance technique that our most significant variables were distance, slope, MBF per acre, and logs per MBF

(to reflect timber size). Again, we sought a means of putting our information in a form useable to loggers. This time, the most useful form was an easily readable table that could be entered with the variables listed above for each skidding method, yielding cost per MBF for skidding (see Table 1). Table 1 gives the cost of skidding for a 25-40 DBHP crawler. Similar tables are given in the publication for 8 other equipment types and classes. This publication is titled, "A Technique for Comparing the Costs of Skidding Methods," by Paul L. Schillings (Intermountain Forest and Range Exp. Sta. Research Paper INT-60, 1969).

Now, lets see how this information can be used to optimize a skidding chance.

Let's assume the following conditions exist for a logger in the field:

- o Stand density 10 MBF/acre
- o Skidding distance 400 ft.
- o Slope 30%
- o No. logs per MBF 14.

How should this material be moved to the landing? Referring to each table in the publication for the nine skidding methods, with the conditions given above, we obtain:

- o Crawler tractor 25-40 DBHP $7.65
- o Crawler tractor 41-60 DBHP 6.72
- o Crawler tractor 61-80 DBHP 4.32
- o Crawler tractor 110-130 DBHP 7.87
- o Rubber-tired skidder 55-80 BHP (Brake horsepower) 4.04
- o Rubber-tired skidder 81-117 BHP 5.63
- o High-lead tower (portable) 9.02
- o Idaho jammer 8.71
- o Shovel (tongs) N.A.

Thus, it can be seen that for these conditions, a small rubber-tired skidder is optimum. Although this data was gathered in the northern Rocky Mountain area, it can obviously be used wherever similar conditions exist.

We are currently working on a method of presenting the results of a study simulating two other logging subsystems--loading and hauling. In the loading study, we have optimized through expected service for:

Table 1.--Operating costs using 25-40 DBHP crawler tractors for three different stand densities commonly found in Montana, Idaho, and northwestern Wyoming

Distance (feet)	Slope (percent)	5 THOUSAND BOARD FEET PER ACRE							10 THOUSAND BOARD FEET PER ACRE							15 THOUSAND BOARD FEET PER ACRE						
		Logs/M bd.ft.							Logs/M bd.ft.							Logs/M bd.ft.						
		4	6	8	10	12	14	16	4	6	8	10	12	14	16	4	6	8	10	12	14	16
		Dollars/M bd.ft.							*Dollars/M bd.ft.*							*Dollars/M bd.ft.*						
200	5	2.99	3.62	4.17	4.67	5.14	5.61	6.06	2.77	3.40	3.95	4.45	4.92	5.38	5.83	2.70	3.33	3.87	4.37	4.85	5.31	5.76
200	10	3.27	3.92	4.48	4.99	5.47	5.94	6.39	3.01	3.66	4.22	4.73	5.21	5.68	6.13	2.92	3.57	4.13	4.64	5.12	5.59	6.04
200	15	3.56	4.24	4.81	5.33	5.82	6.29	6.75	3.25	3.93	4.50	5.02	5.51	5.98	6.44	3.15	3.82	4.40	4.92	5.41	5.88	6.34
200	20	3.88	4.58	5.17	5.70	6.19	6.67	7.13	3.50	4.21	4.79	5.32	5.82	6.30	6.76	3.38	4.08	4.67	5.20	5.70	6.17	6.64
200	25	4.23	4.95	5.56	6.10	6.60	7.08	7.55	3.78	4.50	5.11	5.65	6.15	6.63	7.10	3.63	4.35	4.96	5.50	6.00	6.48	6.95
200	30	4.62	5.37	5.99	6.54	7.05	7.53	8.00	4.07	4.82	5.44	5.99	6.50	6.98	7.45	3.89	4.64	5.26	5.80	6.31	6.80	7.27
200	35	5.06	5.84	6.47	7.03	7.55	8.04	8.51	4.39	5.16	5.80	6.35	6.87	7.36	7.84	4.16	4.94	5.57	6.13	6.65	7.14	7.61
200	40	5.56	6.36	7.00	7.57	8.09	8.59	9.07	4.73	5.53	6.18	6.75	7.27	7.77	8.25	4.46	5.26	5.90	6.47	7.00	7.49	7.97
300	5	3.20	3.88	4.45	4.97	5.46	5.93	6.39	3.06	3.73	4.30	4.82	5.31	5.78	6.24	3.01	3.68	4.25	4.77	5.26	5.73	6.19
300	10	3.45	4.15	4.74	5.26	5.76	6.23	6.70	3.28	3.98	4.56	5.09	5.59	6.06	6.52	3.22	3.92	4.50	5.03	5.53	6.00	6.46
300	15	3.71	4.43	5.03	5.57	6.07	6.55	7.02	3.50	4.23	4.83	5.36	5.87	6.35	6.81	3.43	4.16	4.76	5.30	5.80	6.28	6.74
300	20	3.99	4.73	5.35	5.90	6.41	6.89	7.36	3.74	4.49	5.10	5.65	6.16	6.64	7.11	3.66	4.40	5.02	5.57	6.08	6.56	7.03
300	25	4.29	5.06	5.69	6.24	6.76	7.25	7.72	3.99	4.76	5.39	5.94	6.46	6.95	7.42	3.89	4.66	5.29	5.84	6.36	6.85	7.32
300	30	4.61	5.41	6.05	6.62	7.14	7.64	8.12	4.25	5.04	5.69	6.25	6.78	7.27	7.75	4.12	4.92	5.56	6.13	6.65	7.15	7.63
300	35	4.97	5.79	6.45	7.03	7.56	8.06	8.54	4.52	5.34	6.00	6.58	7.11	7.61	8.00	4.37	5.19	5.85	6.43	6.96	7.46	7.94
300	40	5.36	6.21	6.88	7.47	8.01	8.51	9.00	4.82	5.66	6.33	6.92	7.46	7.96	8.45	4.63	5.48	6.15	6.74	7.27	7.78	8.27
400	5	3.49	4.21	4.81	5.34	5.84	6.32	6.79	3.38	4.10	4.70	5.23	5.73	6.21	6.68	3.34	4.06	4.66	5.20	5.70	6.18	6.64
400	10	3.72	4.47	5.08	5.62	6.13	6.62	7.09	3.59	4.34	4.95	5.49	6.00	6.49	6.96	3.55	4.29	4.90	5.45	5.96	6.44	6.91
400	15	3.96	4.73	5.36	5.92	6.43	6.92	7.39	3.81	4.58	5.21	5.76	6.28	6.77	7.24	3.76	4.53	5.15	5.71	6.22	6.71	7.19
400	20	4.22	5.01	5.65	6.22	6.74	7.24	7.71	4.04	4.83	5.47	6.03	6.56	7.05	7.53	3.97	4.77	5.41	5.97	6.49	6.99	7.47
400	25	4.49	5.31	5.97	6.54	7.07	7.57	8.05	4.27	5.09	5.74	6.32	6.85	7.35	7.83	4.19	5.01	5.67	6.24	6.77	7.27	7.75
400	30	4.79	5.63	6.30	6.88	7.42	7.92	8.41	4.51	5.35	6.02	6.61	7.14	7.65	8.14	4.42	5.26	5.93	6.52	7.05	7.56	8.04
400	35	5.11	5.97	6.66	7.25	7.79	8.30	8.79	4.77	5.63	6.32	6.91	7.46	7.97	8.46	4.66	5.52	6.21	6.80	7.34	7.85	8.34
400	40	5.45	6.34	7.04	7.64	8.19	8.71	9.20	5.04	5.93	6.63	7.23	7.78	8.30	8.79	4.90	5.79	6.49	7.09	7.64	8.16	8.65
500	5	3.80	4.57	5.19	5.75	6.26	6.75	7.22	3.71	4.48	5.10	5.66	6.17	6.66	7.13	3.69	4.45	5.07	5.63	6.14	6.63	7.10
500	10	4.03	4.82	5.46	6.02	6.54	7.04	7.51	3.92	4.71	5.35	5.92	6.44	6.93	7.41	3.89	4.68	5.32	5.88	6.40	6.90	7.37
500	15	4.26	5.07	5.73	6.30	6.83	7.33	7.81	4.14	4.95	5.60	6.18	6.71	7.21	7.69	4.10	4.91	5.56	6.14	6.66	7.16	7.65
500	20	4.50	5.34	6.01	6.59	7.13	7.63	8.12	4.36	5.19	5.86	6.44	6.98	7.48	7.97	4.31	5.14	5.81	6.40	6.93	7.44	7.92
500	25	4.76	5.62	6.31	6.90	7.44	7.95	8.44	4.58	5.44	6.13	6.72	7.26	7.77	8.26	4.52	5.38	6.07	6.66	7.20	7.71	8.20
500	30	5.04	5.92	6.62	7.22	7.77	8.29	8.78	4.82	5.70	6.40	7.00	7.55	8.07	8.56	4.74	5.63	6.32	6.93	7.48	7.99	8.48
500	35	5.33	6.24	6.95	7.56	8.12	8.64	9.14	5.06	5.97	6.68	7.29	7.85	8.37	8.87	4.97	5.88	6.59	7.20	7.76	8.28	8.78
500	40	5.64	6.58	7.30	7.92	8.49	9.01	9.51	5.31	6.25	6.97	7.59	8.16	8.68	9.18	5.20	6.14	6.86	7.49	8.05	8.57	9.07
600	5	4.13	4.94	5.59	6.16	6.69	7.19	7.67	4.06	4.87	5.52	6.09	6.62	7.12	7.60	4.03	4.84	5.49	6.07	6.59	7.09	7.57
600	10	4.35	5.19	5.85	6.43	6.97	7.47	7.96	4.27	5.10	5.76	6.35	6.88	7.38	7.87	4.24	5.07	5.74	6.32	6.85	7.36	7.84
600	15	4.58	5.44	6.12	6.71	7.25	7.76	8.25	4.48	5.33	6.01	6.61	7.15	7.66	8.14	4.44	5.30	5.98	6.57	7.11	7.62	8.11
600	20	4.81	5.70	6.39	6.99	7.54	8.05	8.55	4.69	5.57	6.27	6.87	7.42	7.93	8.42	4.65	5.53	6.23	6.83	7.37	7.89	8.38
600	25	5.06	5.97	6.68	7.29	7.84	8.36	8.86	4.91	5.82	6.53	7.14	7.69	8.21	8.71	4.86	5.77	6.48	7.09	7.64	8.16	8.66
600	30	5.32	6.25	6.97	7.60	8.16	8.68	9.18	5.14	6.07	6.79	7.41	7.97	8.50	9.00	5.08	6.01	6.73	7.35	7.91	8.44	8.94
600	35	5.60	6.55	7.29	7.92	8.49	9.02	9.52	5.37	6.33	7.07	7.70	8.26	8.79	9.30	5.30	6.25	6.99	7.62	8.19	8.72	9.22
600	40	5.89	6.87	7.62	8.26	8.84	9.37	9.88	5.62	6.59	7.35	7.99	8.56	9.10	9.61	5.52	6.50	7.26	7.90	8.47	9.01	9.52

- o frequencies minimum-maximum loads
- o loader reliability history
- o type gripping hardware
- o deck distributions
- o snow covered decks
- o operator efficiency
- o truck arrivals.

Using the output of our skidding studies as input for the loading and hauling, we are optimizing three of the subsystems and thus approaching our goal of optimizing the entire operation from stump to mill.

It should be emphasized that to date our only measure of effectiveness has been the direct cost of logging. Although in most cases we know the method of logging that will probably have the least impact on the environment, we have not yet included these kinds of restraints in our model. However, this will be done before the model will be considered completed.

I know that some of you are already using the results of our studies, and I hope that many of the rest of you will find them useful. I would extend an invitation to any of you here to visit our laboratory anytime you are in our area, and if you have a special logging problem, we would be happy to try to help you solve it. Thank you for inviting me to be on the program today.

TIMBER HARVESTING AND ESTHETICS ARE COMPATIBLE

Gerald J. Coutant
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Alex D. Tocqueville, in his book "Democracy in America," makes the statement, "The American will habitually prefer the useful to the beautiful, and they will require that the beautiful should be useful." These remarks were published in 1835 and have held considerable amount of truth through the years, but a new day is arising. The American public now is saying that the useful should be beautiful. We can see this in many different aspects of the American life, from the putting of utility lines underground, the planning of new subdivisions, the concern over signs and billboards in our cities and along our highways, to the designing of parks and malls in our central business districts, through to the management of our public lands.

In resource planning, amenity values have been taking on increased importance and there is absolutely no reason why our harvest activities cannot be designed to take full consideration of the values that make for a pleasant landscape. There is no reason why resource management and timber harvest cannot complement the natural landscape, adding to its variety and interest rather than detracting from it.

S. Dillon Ripley, the Secretary of the Smithsonian Institute, in writing an introduction to Nathanial Alexander Owings' book "The American Esthetic," had this to say, "Among all of the professions I would urge the natural scientist to give special attention to these thoughts, for they are needed more than ever as part of the team. It is incumbent on biologists to believe in the possession by Americans of an esthetic sense, however much the evidence of their eyes may aver to the contrary. For biologists must join with students of the social sciences and the arts in a common purpose, to create a study of which I have called 'social biology,' in which the true principles of ecology can be applied to social and urban studies of the city environment." Mr. Ripley's remarks can certainly be applied to the rural environment and the environment of our wild lands as well.

The planning that we are talking about has to be done as a team. We have to approach it as a team because the problems that confront us in resource management are as difficult to solve as the problems confronting us in social and environmental sphere. They become more complex with each passing day. Arnold Toynbee has said that as the society or civilization runs out of challenges, it runs into decay. Challenge, he says, is essential to produce existence. Well, we certainly are not running out of challenges as we move into this decade of the 70's.

I would like to explore with you for a few moments this afternoon the opportunities that the design profession, together with the biological professions, have at their fingertips in the management of our natural resources, specifically where timber harvest and esthetic values seem to be in conflict.

To begin, one must define his terms, and I don't think I have to define timber harvest for you, but I should attempt to define the term esthetics. To do this is a difficult challenge. Involved are questions of individual and relative taste. The concepts of beauty have grown with time and experimentation together with the principles of design. Some are more concrete than others. The more all encompassing one tries to make this definition, the more elusive the goal seems to be.

Whether an individual is creative or responsive to art is not important; some will simply reach out of the mediocre to say "I like what I like." There is in that act an undeniable act of receptivity and judgment. I contend that even the most boorish individual has some sense of esthetic quality because of his environment and communications media during the past decade.

Training and example are as fundamental in the development of an esthetic sense as is skill. We are training our children in the fine arts as they develop in the educational system. As our society becomes more affluent, our desire for esthetic quality and esthetic values grows. One can see this in the amount of art purchased today. Here in western Montana, for example, the number of art galleries is considerable, considering the fact that Montana's population is relatively small.

The word esthetics comes from a Greek word "estheticos" which refers to impressions received through the five senses. Esthetic or esthetics tries to help explain what beauty is and how it may be recognized. It really helps mankind understand the value of art and how art affects the mind of man. This is certainly not lost upon Madison Avenue or any of the merchandizing profession. Next time you go to your grocery store look at the packages on the shelves--the colors, the shapes and sizes of containers, are all related to things you know and with which you are familiar. This is not done by accident, but by <u>design</u>. The design professions, using the components of esthetics, have created something you want to buy. These techniques can be used in resource management as well.

J. W. Duffield, writing in the August issue of the "Journal of Forestry," says that most of the foresters have chosen the profession of forestry for reasons that are basically esthetic--the sights, the sounds, and the smells of the forest are so attractive that we decide we want to spend much of our time exposed to them. He says that probably our professional training and experience may have caused some of us to forget these feelings. Young foresters are constantly hearing more of the importance of being practical, of gaining experience, and of being economically realistic. Although these virtues are undeniable, he says they can make "Jack a dull boy."

What we must begin to do in reality is to tie the esthetic values to the economic realism. This is a necessity in weighing the issues. And this can be done, except that our people working in areas of management of land have to have some design knowledge, along with their biological training. I don't believe that it is a matter of not cutting timber, because this is not the answer either. We must be able to produce timber and cut it and we should be able to maintain scenic values of a forest landscape through change, since the forest is a dynamic entity in itself.

There will be times when problems will arise where timber production and esthetic views are sometimes in conflict. This is bound to happen.

What you gentlemen are talking about here today can offer a great deal to the manager of lands, public and private, because harvesting small logs can materially add to the relationship of esthetics and economic values being compatible. In many cases, cutting may in fact be used as a landscape technique to enhance the value as seen from the road. An example is the occasional need to clear away roadside vegetation to permit viewing the adjacent scenery, such as a lake, stream, or mountain. We might want to vary the edges of a clearcut by designing the shape of the clearcut to avoid the abrupt lines. This may help reduce the negative impact of the cutting unit itself. It is usually the contrast that is created by the cutting unit that caused the public's attention to be drawn to the activity. The openings created by cutting or thinning can create an interesting and even an exciting landscape by adding contrast and variety.

The assumption is frequently made that "good" scenery results more or less automatically in some natural occurring situations. But this is not necessarily the case. Several times during sessions that we held here in the Region on the subject of the natural beauty, the comment was made, "How can we improve on the natural beauty of the landscape?" You can improve on it by using the techniques of the design professions. And I contend that the optimum visual results cannot be expected to occur spontaneously. We must actively consider and pursue the values we want to achieve adjacent to any roadway, mountain way, or any viewing area. Good management of these lands should be based upon an analysis of all variables we have discussed. Thereupon we will come up with a landscape which is not only pleasing to people, but utilitarian as well.

What we can attempt to attain is the naturalness by avoiding straight lines or abrupt changes from the natural to the manmade landscape.

Since most of the landscape we are talking about is the ordinary landscape and not the spectacular landscape, the emphasis should be placed upon naturalness rather than uniqueness, and there is the point that sometimes is forgotten.

Although beauty is complex in its relative characteristic way as we have said previously, there are concepts of visual composition such as balance, harmony, unity, contrast, form that we can apply to the forest landscape to create beauty where it was absent. Although these concepts have been used in the design profession such as architecture, art, engineering, landscape architecture for many years, there is no reason why we cannot use them to our benefit in resource management.

There is an old English saying that applies to architecture, "that well-built hath three conditions, commodity, firmness, and delight." This applies to other types of design and management as well. I believe we have an opportunity to utilize the smaller size logs to a greater degree than has been utilized in the past, one which will result in economic and esthetic gain for the American public.

The concern for better environment is not going to lessen. The planned obsolescence of the past of much of our material resources will have to be reduced. Rather than look at it from the negative standpoint, I think we should look at it from the positive and attempt to solve our problems. Let us begin by creative utilization of more of our forest resources than we are using at present.

This afternoon I would like to show you slides of some of the techniques that we have been using; some of the techniques in which we are training our people; and some of the opportunities that we have in managing the forest landscape.

I will take you down a highway through a river valley with many stagnated stands of timber; with many opportunities to improve the visual experience of the public traveling the road. This public includes both the local inhabitants and the traveling public.

I want to make this point because of the contention that improving the visual experience, as seen from the roadway, is an improvement done for the recreationist. We are improving the environment through which people pass, moving from one point to another, while utilizing the natural resources for everyone.

This is not a simple matter, but requires the analysis and study of the valley by several disciplines. The climax of this study is a coordinated plan that optimizes returns to the public and landowner. The best way to show this type of management is through the use of slides. I will show you the valley as it was left after the road was completed--without management and again with management. I will let you decide which is the best experience for people. The esthetic and the silvicultural considerations together have provided a pleasing landscape of which any land manager could be proud.

We can use this same approach on any landscape before the road location is determined, which will give us greater control over the manipulation of the vegetative cover. Since the land and vegetation on it are dynamic forces, change is inevitable; the planning must take this into consideration.

The opportunities for improvement throughout the northwest grow with each passing year. The Forest Service Intermountain Experiment Station has determined that one-third of the forest lands of the west have stands of stagnated trees. Some of these stands would be of pole size providing an opportunity for harvest or thinning. There is everything to gain and nothing to lose in the strengthening of the small log industry where the harvesting of timber and esthetic quality can be compatible.

SMALL LOG HANDLING AND SORTING

J. H. Porter
Chief Engineer
CAE Machinery Ltd.
Vancouver, B. C., Canada

Several papers have been published recently indicating the desirability of log sorting for small log sawmills. Very little has been said about log sorting equipment. The purpose of this paper is to discuss some of the most modern equipment available to the industry. As the chief engineer of CAE Machinery Ltd. my work is concerned with the development, design, and manufacture of sawmill machinery. I will not discuss whether or not any particular mill should use log sorting. This is the function of the sawmill designer. It is intended that this paper will provide sawmill designers and owners with information which will assist in their assessment of equipment for sorting small logs.

The information which follows is based upon the experience of AB Hammars Mekaniska, Nyland, Sweden, designers and manufacturers of log and lumber sorting equipment, REMA Electronics, designers and manufacturers of specialized, integrated circuit control systems for log and lumber sorters, and work which has been carried out by CAE Machinery Ltd., Vancouver, in the development of such equipment.

This discussion will cover--

(a) the log sorter

(b) the infeed

(c) the discharge

(d) measuring and programming

(e) log sorting system at Northwood Mills Ltd., Princeton and Okanagan Falls, British Columbia.

(f) log sorting installation, AB Kaukas, Finland.

Films:

Two films will also further illustrate the systems as follows:

(a) Dry land sorting of logs into bins, Gruvon, Sweden.

(b) Kaukas, Finland, log sorting installation.

What is Log Sorting?

Log sorting is the dividing of random sized logs into groups where the division may be in diameters, or lengths, or species, or grade classifications.

The systems discussed will normally be capable of handling logs between 4" and 16" diameter, and up to 24' in length. When considering the processing of small logs it is important to remember that for a given length the volume is proportional to the diameter squared. A 12" Ø log has four times the volume of a 6" Ø log, and a 24" Ø log has 16 times the volume of a 6" Ø log if all the logs are the same length. Therefore, in order to process 6" Ø logs on an economical and competitive basis, the processing must be carried out at something in the order of 1/16 the cost of a 24" Ø log. One way of improving production efficiency is to process the logs rapidly in a through-line process. In order to allow continuous runs in such a system the use of log sorting will enable groups of logs of selected diameter ranges to be processed continually and in close succession without stopping to allow for adjustment of heads and/or saws between logs. This is an important feature as large gaps between logs, and stoppages to change heads result in lost time and reduced production efficiency.

Advantages of Sorting:

(1) Presetting:

Log sorting will allow the presetting of equipment, and hence continuous runs.

(2) High Speed Operation:

High speed operation is obtained by having logs sorted to diameter, and passed in close succession through in-line, preset, processing equipment.

(3) Reduced Handling:

A well designed system will considerably reduce the necessity of log handling, and particularly the manual manipulation of logs.

(4) Manpower Savings:

In a well designed and built system considerable manpower savings can be achieved.

Disadvantages of Log Sorting:

(1) Initial Cost:

This must be carefully investigated to ensure that log sorting will be profitable for each individual mill. A log sorting system is much more than a collection of conveyors. Therefore it must be designed and built as an efficient machine, and care must be taken to ensure that cost reduction does not result in a poor system which is also a poor investment.

A. How are Logs Sorted?

Systems for sorting logs include the use of boats and current flow in lakes and on the coast, and the use of front end loaders on dry land. These types of sorting are suitable for the handling of small quantities of large diameter logs. They are not suitable for handling and sorting, to accurate diameter groups, large numbers of small logs. For this situation it is necessary to use high speed, automatic, mechanical sorting systems.

(1) Mechanical Sorting Systems:

(a) Concave Rollcase Sorting Conveyor:

Over many years concave rollcases have proved to be a good method of conveying logs. When applied to log sorting systems they are, however, at a disadvantage as logs of varying diameter move over the rolls at varying speeds. With such a system it is therefore necessary to use limit switches or other detecting devices along the length of the sorting conveyor in order to control the discharge. If kicking is on both sides, then the detecting devices must be located in between the rolls, beneath the logs. As a result of this the detectors are subject to repeated malfunction. This is partly due to uneven log surface which results in unpredictable operation. It can also be caused by wood rot and bark getting into the mechanism.

(b) Sorting on Chain Conveyors:

If the logs ride directly on the top of chains there is still no real advantage over the concave rollcase as control is still not sufficiently positive.

(c) Sorting Conveyor using Chains with V-Flights (See Figure 1):

The use of chains with V-flights gives positive control of the logs as they move along the sorting conveyor. Troublesome limit switches are not necessary if a pulse count or magnetic drum memory system, which is synchronized with the conveyor movement, is used. This gives good control, and enables the incorporation of such features as the discharging of logs centrally into bins or decks, regardless of length.

In order to reduce the number of conveyors required it is preferable to discharge logs on both sides of the sorting conveyor. This discharge can be performed by the use of kicker

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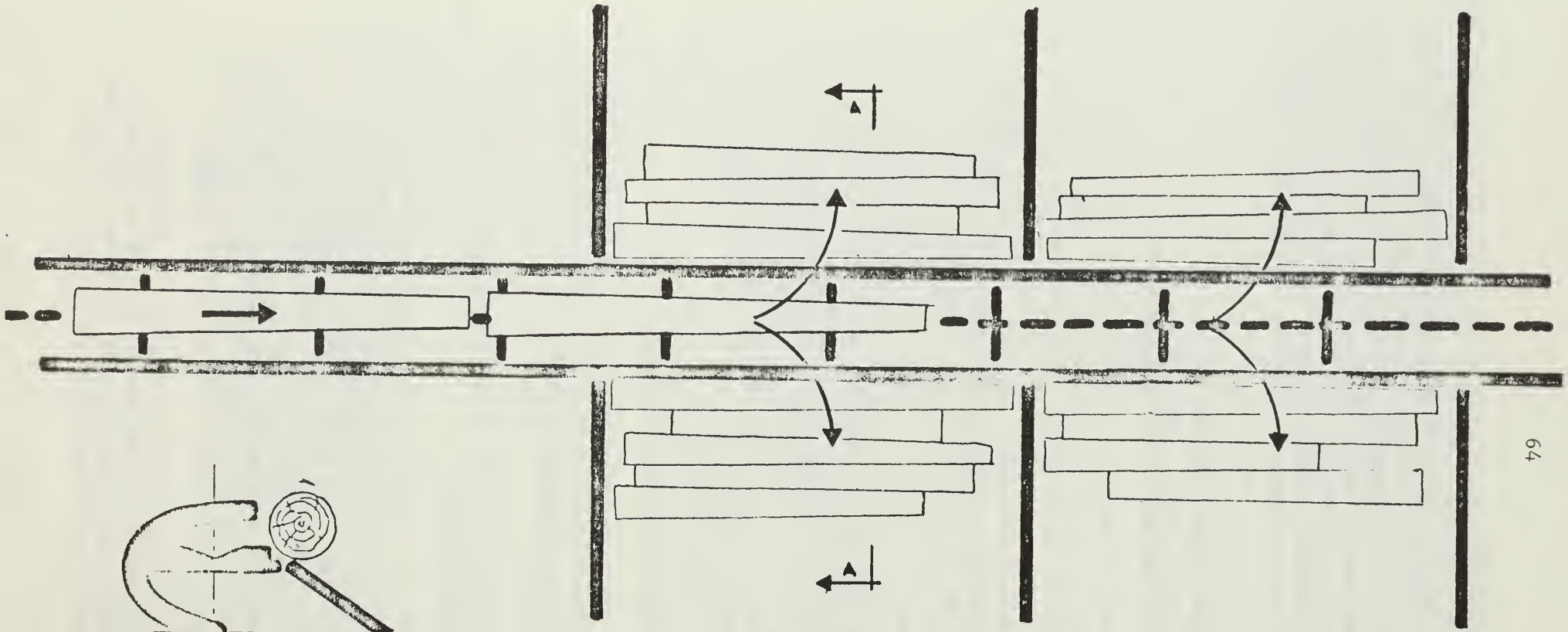

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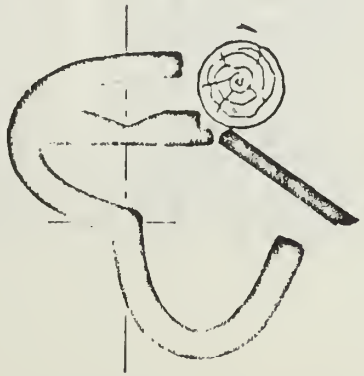

SECTION 'A-A'
LOG BEING KICKED

LOG SORTING
LOGS MOVING IN LINE

FIGURE #1

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arms which kick in both directions and centralize, or by having the conveyor sides arranged to drop away. The former system enables logs to be fed in close succession regardless of length, whereas the latter system is such that all logs must be spaced in a spacing which is based on the length of the longest log. Sorting conveyors with drop sides will have a smaller capacity for a given forward log speed.

The above refers to logs which are moved in line, one behind the other. Such systems are by far the most common type used for sorting logs. However, consideration should also be given to possibilities of sorting logs where the logs move transversely. Two such systems are as follows:

(1) Logs moving transversely across decks, with gates discharging logs to rollcases below.

This type of system is good for logs which are moving slowly, and which are of full tree length and up to 60 ft. long. The disadvantage is that it is very difficult to develop gates which will operate satisfactorily at high speed to both carry logs across and discharge as necessary.

(2) L-Bar Sorters:

L-Bar sorters are already being used in fairly large numbers for sorting lumber. A further development of such a system is to modify this design to handle small logs. Such a system will have very high production capabilities with the possible ability to handle logs up to something in the order of 45 logs per minute. This is something over twice the capacity that can be expected to be obtained with an in-line sorting conveyor. However, the L-Bar system will be expensive as all equipment must be suspended well above the ground, and rugged bins or carts must be provided to accept the logs as discharged. Further handling will be required in order to move the logs from the sorter to storage bins.

B. Log Infeed System:

(1) Crane:

A crane is used to load individual logs onto the sorting conveyor. This is a very slow speed system.

(2) Mobile Equipment and Simple Log Deck:

Mobile equipment is used to load bundles onto a deck. The

logs are unloaded onto a sorting conveyor by means of a knuckle boom hoist. This is a slightly faster system than system (1), but is restricted to a maximum of 10 logs per minute.

(3) Mobile Euqipment with Unscrambler and Log Loader (See Figure 2):

Logs are loaded onto a storage deck. From this they are fed onto a single layer deck, then to an unscrambler and a log loader which feeds one log at a time to the sorting conveyor. When automatic controls are used up to 20 logs per minute can be handled.

(4) Merging Infeed:

Once logs have been loaded into a conveyor, and are travelling axially, it may be necessary to pass these through a debarking and bucking system. Where high production is required with a sorting conveyor running at approximately 300 ft. per minute it will be necessary to pass the logs through two debarking and cut-off saw lines, due to the lower maximum capacity of this equipment. After this it will then be necessary to bring the logs into an automatic merging section where some storage can be provided, and where the logs are transferred and fed intermittently into a single, high speed, sorting line. See figures 3) and 4).

C. Log Discharge:

As stated previously, the system should be arranged so that the logs land centrally in storage bins, or transfer decks. This will balance the load and reduce the tendency for logs to skew, and the loads to become unstable, particularly when there is considerable length variation.

(1) Storage Bins:

These should be ruggedly designed, and great care should be taken that the unloading equipment and storage bins are designed to suit each other. If not, difficulties can be expected in unloading bins. Also, the possibility of considerable damage to the equipment exists from the heavy and powerful mobile equipment being used, if the design is poor. See figure 5) and 5a).

(2) Storage Decks:

In order to reduce the necessity for rehandling of logs by mobile equipment, it may be advantageous to feed directly onto storage decks. The operation of storage decks should be such that a pile of logs, several logs high, is automatically built up, with the transfer conveyor inching forward as the pile is built up, so that a continuous layer, several logs high, is eventually built over the full length of the storage conveyor. When the conveyor becomes loaded to capacity, this condition should then be detected, and the operator informed so that he can transfer the incoming logs to a bin whilst the transfer deck is unloaded. The transfer decks are otherwise similar to the decks used for automatic

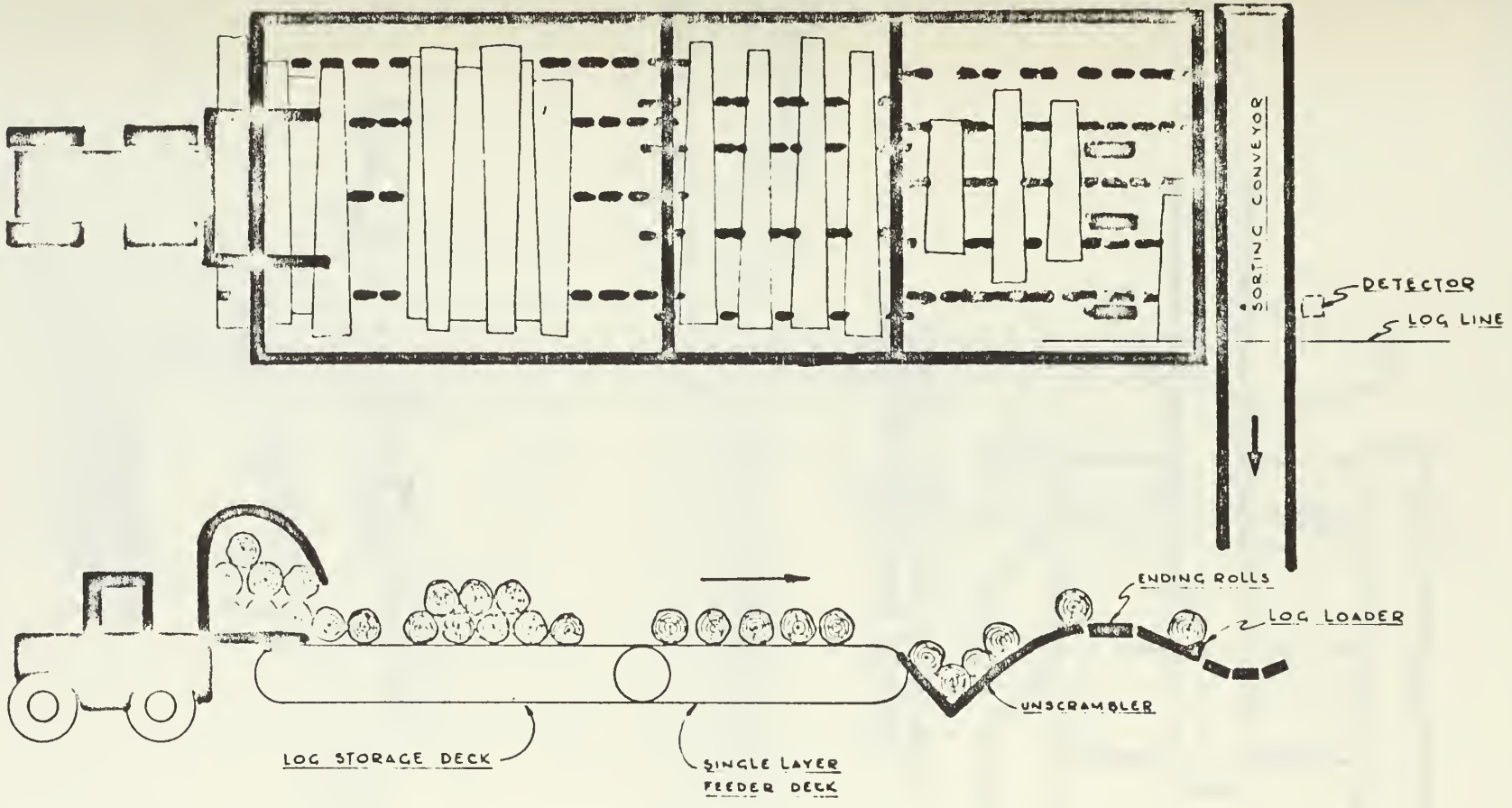

FIGURE # 2

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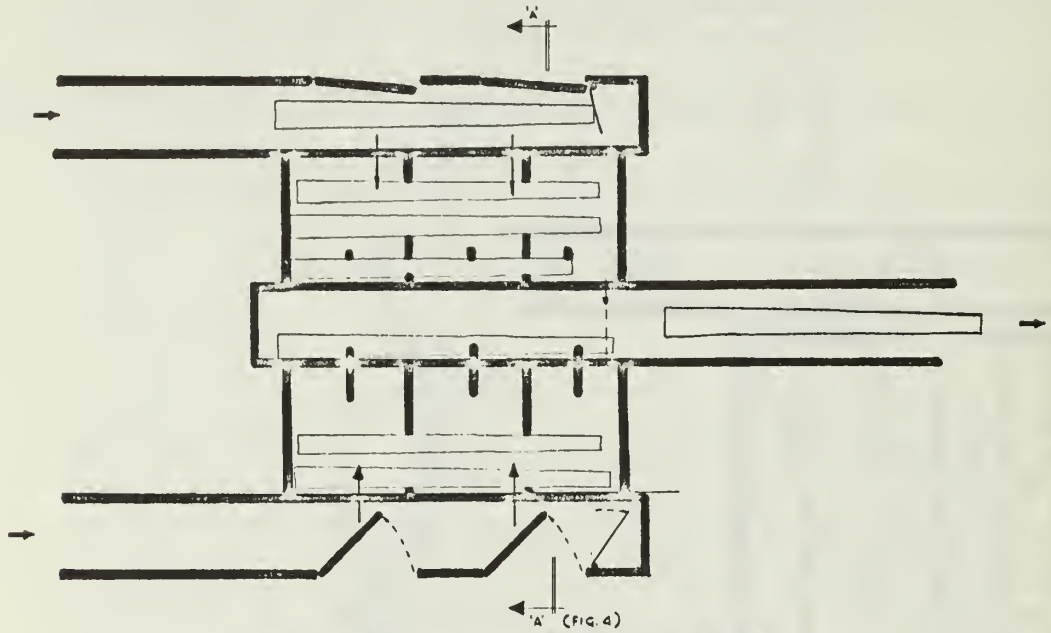
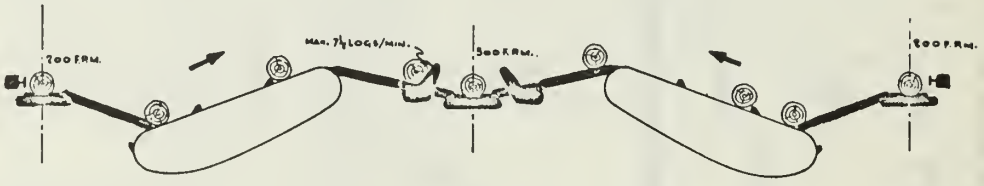


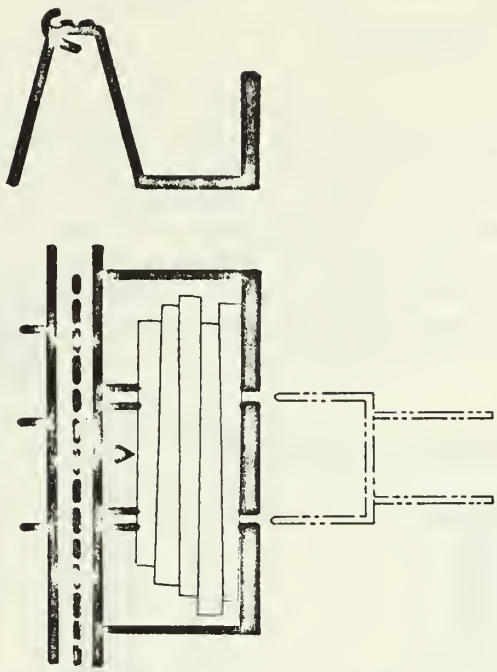
LOG SORTING FEED SYSTEM
DOUBLE FEED WITH STORAGE

FIGURE # 3



SECTION 'A-A'
AS SHOWN ON FIGURE # 3
& FIGURE # 8

FIGURE # 4



DISCHARGE INTO BINS

FIGURE #5

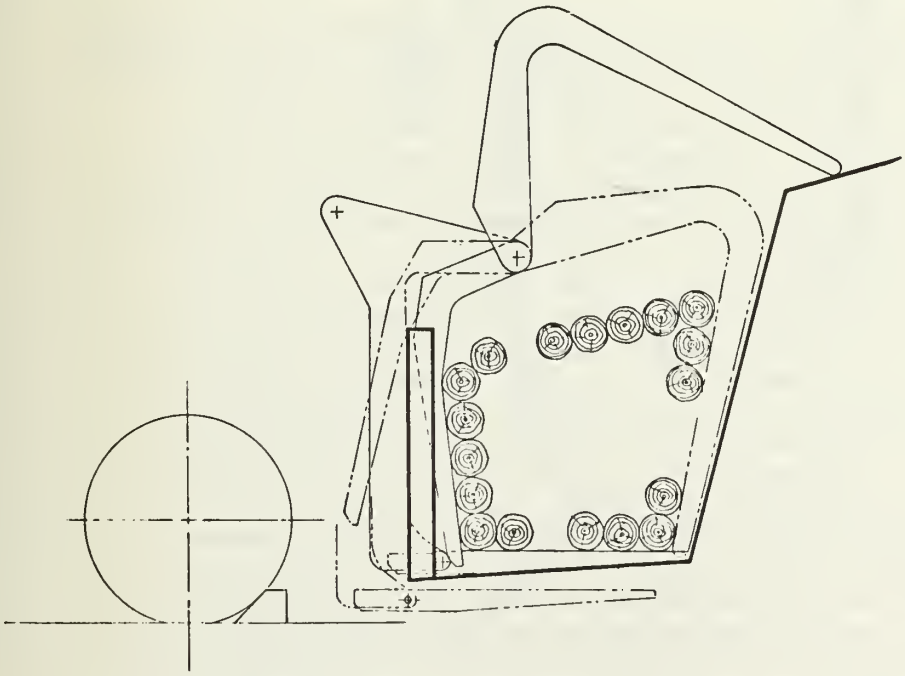


FIGURE #5A

infeed systems when loaded from mobile equipment. The logs are pulled out, one at a time, into a single layer, before being fed through an unscrambler and loader arrangement for one-at-a-time feeding onto a conveyor. See figure 6).

D. Log Measuring and Programming:

This can be carried out by manual operation, but in a high speed operation with up to 20 logs per minute being processed this is not practical. An operator does not have the ability to make judgments of diameter, and to make these judgments at a rate of 20 per minute on a continuous basis. For slow speed systems, where accuracy is not a requirement, manual decision making may be satisfactory, but if we remember that the relationship between diameter and volume is proportional to the square of the diameter, it will soon be appreciated that errors in diameter measuring can be extremely costly.

(1) Automatic Measuring Devices:

Two basic types will be considered:

(a) Mechanical.

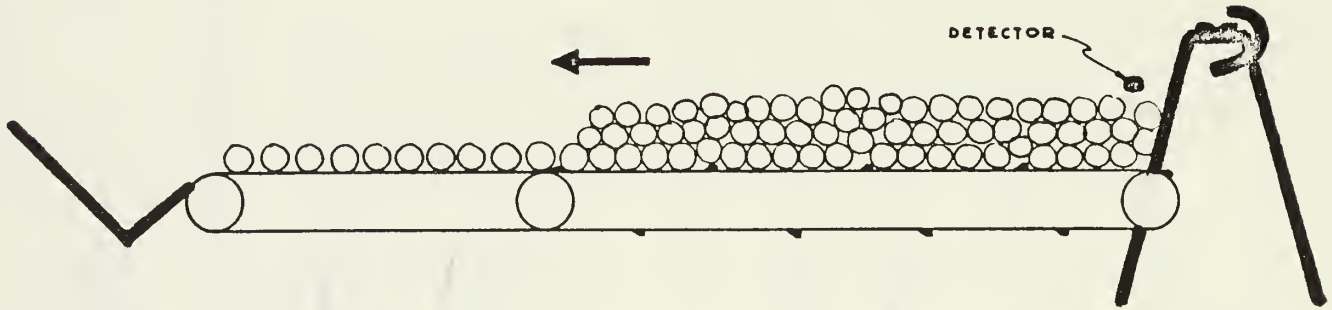
(b) Electronic.

(a) Mechanical Measuring Devices:

These devices which usually consist of a skid or wheel which rides over the top of the log do not provide accurate measurement due to the wheel or skid bouncing over the uneven log surface. Maintenance of such equipment is costly.

(b) Automatic Electrical and Electronic Measuring (See Figure 7):

One very successful, automatic log measuring device is produced by REMA Electronics. This device, in its simplest form, consists of a light source on one side of the log, with a parabolic mirror on the other. As a log passes between the light source and the parabolic mirror, a shadow equal to the diameter of the log is created on the mirror. As the mirror has a parabolic form, the depth of the shadow can be measured as an angle from a given point, this angle being proportional to the log diameter. In the REMA system this angle is measured by a rotating mirror which projects the angle of the shadow onto a photo cell as the mirror rotates, and the photo cell and associated electronics count the pulses, each pulse being equal to 1/8" diameter so that the log is measured in 1/8" diameter increments to an accuracy of 1/8". As the log passes through the scaler, the diameter will vary due to taper so that if measurements are continually taken along the length of the log, a number of diameters can be measured, one for each rotation of the rotating mirror.. The associated electronics can be supplied with various options which include the following:



DISCHARGE ONTO DECKS

FIGURE * 6

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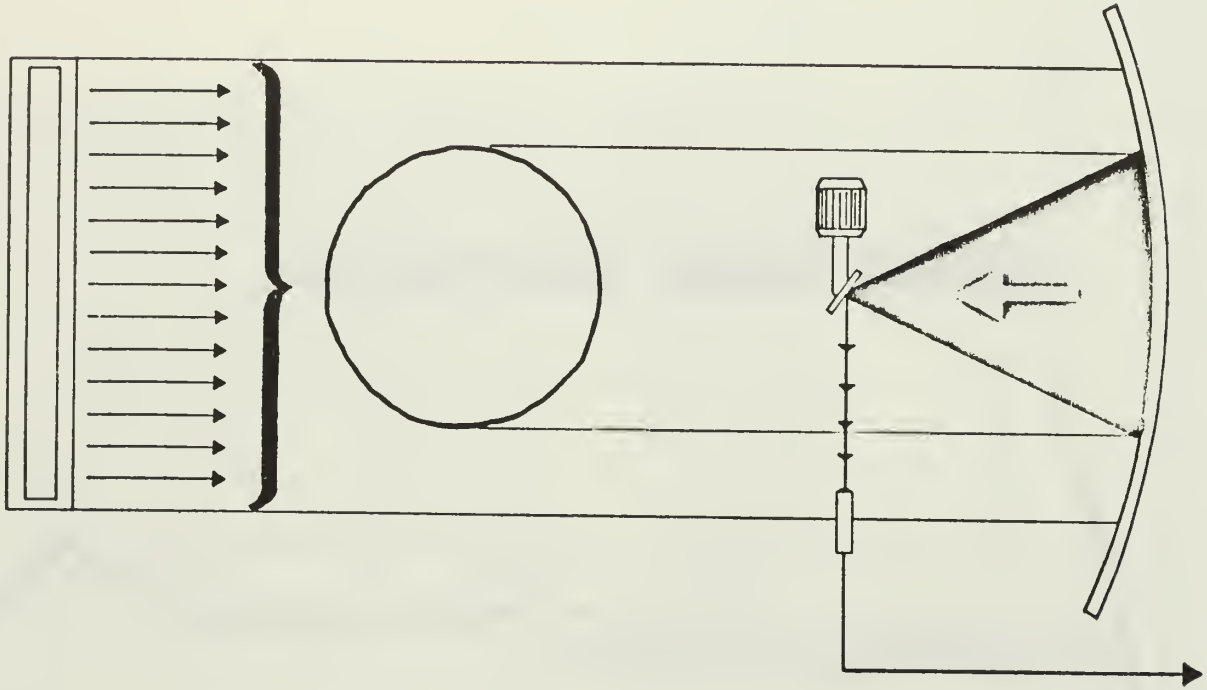

FIGURE # 7

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1) Small diameter measuring.

2) Large diameter measuring.

3) Average diameter measuring.

4) Length measuring.

5) Volume measuring.

In some sophisticated systems such as the one installed at AB Kaukas, Finland, the scaling is also done from three directions in order to improve accuracy, and all the information is fed into a computer which records, analyzes, and gives printed information for the logs, as sorted.

This scaler is a key piece of equipment and, being quite versatile, it can have many functions. It can be a key to measuring of mill efficiency by accurately measuring the total volume of wood passing into the mill which can then be compared to the total volume of lumber produced in a given period.

Other equipment associated with the scaler includes:

1) A manual address override.

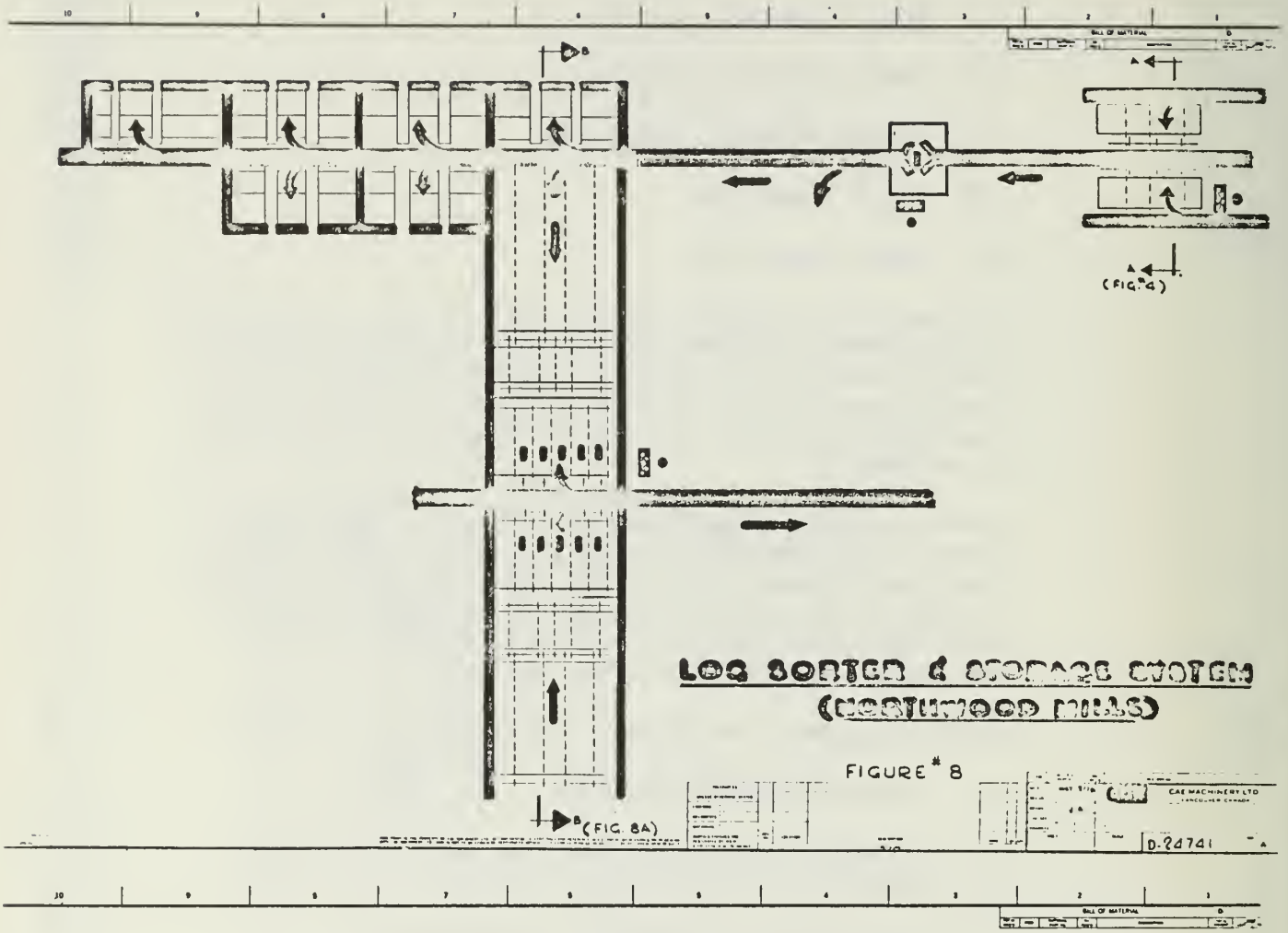
2) A display which indicates the information being measured (in increments of 1/8").

3) Patchboard for programming the sorts or dimension groups to bins.

4) Pulse generator. This is connected to the tail shaft of the sorting conveyor, and is arranged in such a way that a log travelling the full length of the conveyor would result in 1,000 pulses being generated. If a log, therefore, has to be discharged at a point half-way along the conveyor, the programming and memory system relates this to that particular size of log when it is measured so that it counts down 500 pulses before the kicker of that particular bin operates to discharge it.

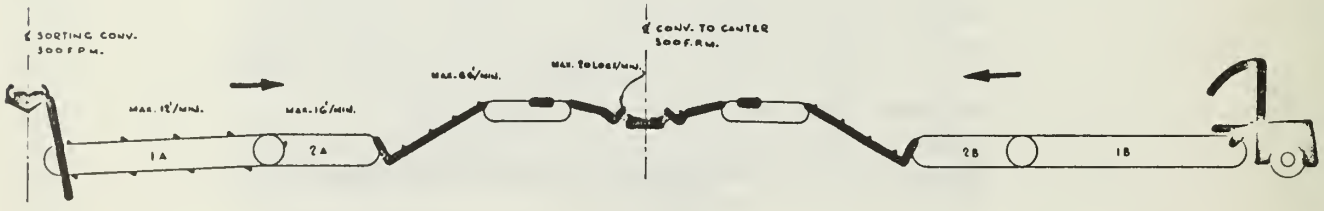
E. Log Sorting Systems for Northwood Mill, Princeton and Okanagan Falls, B. C. (See Figure 8):

This system uses the basic Hammars principles as developed for Scandinavia, with certain modifications and developments to suit the equipment to local conditions. It is the second log sorting system produced by CAE Machinery Ltd., in co-operation with Hammars. The requirements of this system were laid down by Mr. Brodie Gillies, the chief engineer for Northwood Mills Ltd., and Messrs. Phillips, Barratt, Hillier, Jones & Partners, Consulting Engineers, Vancouver. All detailed design work and



LOG SORTER & STORAGE SYSTEM
(WESTWOOD MILLS)

FIGURE * 8



SECTION 'B-B' (FIG. 8)

FIGURE * 8A

manufacturing has been carried out in the CAE plant in Vancouver, British Columbia.

The requirements of the Northwood systems are to sort logs by small end diameter into six sizes as follows:

4 to 4-7/8"

5 to 5-7/8"

6 to 6-7/8"

7 to 7-7/8"

8 to 11-7/8"

12 to 16".

Log lengths will vary between 8 and 24 ft. Required capacity for this system is an infeed of up to 15 logs per minute, and and outfeed of up to 20 logs per minute.

(1) Infeed:

After logs have been barked and sorted to length, they flow in two lines into the system. These two lines are automatically merged into one system so that the logs flow into one sorting line on an intermittent feed basis. This infeed is fully automatic, with manual override controls.

(2) Sorting Conveyor:

The sorting conveyor runs at a speed of 300 ft. per minute.

Scaling:

The REMA scaling system is used, and will be initially arranged for automatic top diameter measuring only.

(3) Discharge:

The "hot" sort will be discharged onto a transfer deck where log storage is automatically built up from which the logs can be rapidly and automatically fed onto the discharge conveyor. Logs which are discharged into the storage bin can be transferred by mobile equipment into a second storage and feed deck from which the logs can be fed automatically into the discharge conveyor.

(4) Discharge Conveyor:

The discharge conveyor will feed the logs at 300 ft. per minute into a canter with very close spacing between each log.

(5) Operators:

The system is designed for one operator to overlook the sorting and storage process, and to police and control the feeding of the logs from the storage decks into the discharge conveyor. The merging infeed to this system will be policed by a cut-off saw operator who, in an emergency, can operate the override controls for the merging infeed section.

F. Log Sorting at AB Kaukas, Lapientra, Finland (See Figure 9):

Requirements of this system are as follows:

1100 logs per hour.

80% fir - 20% spruce.

6 to 16" diameter, with some up to 30" diameter.

Length: approximately 21 ft.

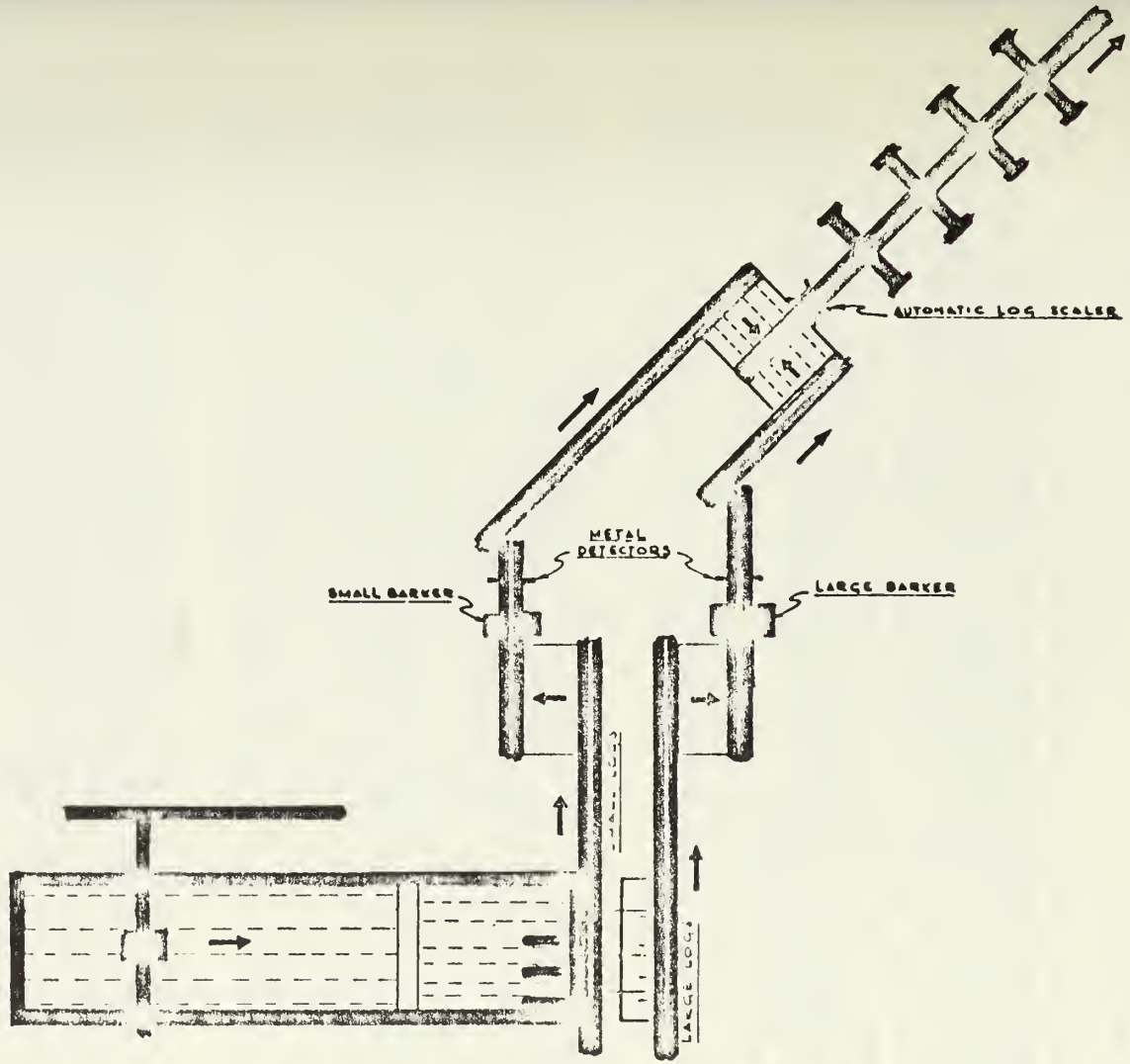
Less than 16" diameter will go to a small barking line at 230 ft. per minute. Over 16" diameter, and some of the smaller logs will pass through the large barker at 165 ft. per minute.

Sorts required are 12 sizes, 3 grades, plywood, and pulpwood. Measuring is carried out automatically in three directions, with full information going into a computer.

Operators:

Crane	1
Log Pond	2
Knuckle Boom	1
Barker	1
Grade Sorting	1
Bundling	3
Total	9 operators.

This sorting system was custom designed and built by Hammars to suit Kaukas' special needs, and apart from breaking of the bundles at the infeed, and the bundling of logs on the sorting line, there is no direct man-handling, with most of the operations being automatic. All logs flow through the system under full control of the equipment, with automatic measuring, feeding, and transferring from one section to another. The system consists of one automatic feeding deck feeding two fast debarking lines. The two lines are brought together onto one fast sorting conveyor, and the logs are automatically scaled and sorted. Ahead of the infeed bundled logs are towed to the intake where a special overhead crane is used to transfer them onto the feeder deck. Logs can also be transferred from trucks or railroad cars. Each bundle which is transferred from the water consists of about 80 logs. As each bundle is lowered onto the infeed deck, it is turned through 90°, and then, after lowering, the lifting wires are automatically disconnected. Close to the unloading zone is a knuckle boom turner. This is used to turn the butt ends of the large logs in the direction of travel, and also to help generally



LOG SORTING SYSTEM (KAUKAS)

FIGURE *9

BILL OF MATERIAL
CAE MACHINERY LTD
VANCOUVER CANADA
D-24741

to start the unscrambling process. The logs are fed over the unscrambling system, and automatically fed, one at a time, into the two debarking lines. One operator watches over the log movements from the feeder deck to the debarking machine. He has controls with which to override the automatic functions in an emergency.

The logs below 16" diameter are passed through the small barking machine at 230 ft. per minute, and the larger logs are barked at 165 ft. per minute.

After barking, the logs pass two metal detectors, one on each line, which automatically separate "metal logs" onto a deck before they reach the scaling house. The logs then proceed in two lines into the scaling house where they are brought together into one rapid sorting line (350 ft. per minute). This is done by means of two transfers, and a special, intermittent feeding arrangement. The transfers also provide buffer zones to ensure that the barking can be continuous. The measuring is done automatically in increments of 2-1/2 cm along the length of the log, in three directions.

THE INTERRELATIONSHIP OF MINERAL ECONOMICS, MINING SYSTEMS, AND MINING RESEARCH

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Introduction

In assessing mineral supply economics in the United States today, two main influences stand out. These are (1) the sustained high rate of economic growth and (2) the revolutionary impacts of science and technology on the materials demand sectors.

To supply these minerals at an acceptable real cost, the mining industry is faced with a challenge to rival any in its history. All the traditional problems of mining are still with us today, and many of them will become even more severe. New pressures and constraints, which were insignificant or nonexistent considerations in the past, are being imposed on mining. Not only national but international socio-political problems and issues enter into the picture.

Before the 1960's, an average growth rate of 3 percent per year in the GNP was generally accepted as sustainable. Actual experience since 1950 has shown GNP growth in constant dollars to be from 3.5 to 4 percent annually. To the year 2000, the GNP growth rate is predicted as 4 percent. Population growth is predicted at 1.6 percent and industrial production at 4.2 percent. In 1950, the Paley Commission predicted that future trends of technology in the primary mineral resources industries might not be able to cope with the growing need to exploit lower grade raw materials to meet the rising demand within the current price structure. Now, 20 years later, there is increasing evidence that the Paley Commission's fears regarding lagging technological progress in the mineral supply industries have been realized (Table 1.).

Technology must be applied to broadening the recoverable portion of the resource base through development of new techniques of exploration and discovery; lowering the cost of development of reserves presently classified as marginal and submarginal; extending mineral supply through recycling; maximizing the recovery and utilization of byproducts and co-products; and assuring the maintenance of the quality of the environment during the entire minerals cycle.

There should be a "goal oriented" approach to minerals planning, programing, and management. To an increasing degree, technology, as well as the measures with which to meet economic and social needs, can be literally planned, programed, and managed into reality.

TABLE 1. - Value of world primary demand for minerals, 1968, and forecasts to the year 2000
(Billion constant 1968 dollars, except as noted)

Commodity Group	1968	Forecast range, 2000		Cumulative demand 1968-2000		Growth rate (percent)	
		High	Low	High	Low	High	Low
				UNITED STATES PRIMARY DEMAND			
Energy	20.4	103.2	48.1	1,740.3	1,087.0	5.2	2.7
Ferrous	2.0	6.1	4.3	116.1	94.4	3.3	2.4
Nonferrous	5.5	52.0	26.9	679.6	466.1	7.3	5.1
Nonmetallic	5.8	27.3	17.6	415.8	326.8	4.9	3.5
Total	33.7	188.6	96.9	2,951.8	1,974.3	5.5	3.4
				REST OF THE WORLD PRIMARY DEMAND			
Energy	35.9	184.8	110.1	2,919.1	2,066.1	5.3	3.6
Ferrous	7.1	20.4	14.3	393.4	326.1	3.3	2.2
Nonferrous	15.5	132.2	62.9	1,464.3	948.3	6.9	4.5
Nonmetallic	24.3	119.1	81.2	1,871.3	1,477.7	5.1	3.8
Total	82.8	456.5	268.5	6,648.1	4,818.2	5.5	3.7
				TOTAL WORLD PRIMARY DEMAND			
Energy	56.3	288.0	158.2	4,659.4	3,153.1	5.2	3.3
Ferrous	9.1	26.5	18.6	509.5	420.5	3.4	2.3
Nonferrous	21.0	184.2	89.8	2,143.9	1,414.4	7.0	4.6
Nonmetallic	30.1	146.4	98.8	2,287.1	1,804.5	5.1	3.8
Total	116.5	645.1	365.4	9,599.9	6,792.5	5.5	3.6

Mining Problems of Today

Traditional problems, such as increasing mining depths, decreasing grades, and higher costs of goods, materials, and labor, are recognized challenges to industry management. Less direct but more difficult to define is an entirely new set of problems brought about by public reaction which has resulted in legislation at both State and national levels. One highly publicized result of this interest has been the recent health and safety legislation for both coal and metal mining.

Congress and the Executive Branch have responded to public concern about our environment--witness the Wilderness Act of 1964; the Clean Air and Water Quality Acts of 1965; the Clean Water Restoration Act of 1966; and the Air Quality Act of 1967. Many States have also responded to these same pressures. State laws regulating certain types of surface mining have increased steadily in the past 11 years. While only six States had such regulations in 1959, today at least a score of States have them. It is only realistic to assume that national concern over land, air, and water environments will result in further legislation.

Such legislation, with emphasis on regulations designed to minimize degradation of environmental quality, will result in higher mining costs. Granted there is strong evidence to indicate that, given a choice, people will pay the substantially higher costs associated with mining a mineral at minimal environmental disturbance. However, this is not the whole answer. Complacency can price many mining operations right out of business.

The fundamental problem can be simply stated. There are essentially three ways that a country can assure an adequate mineral supply. These are (1) to discover new mineral occurrences which constitute "ore" within the boundaries of the country, (2) to import minerals, or (3) through continuous research and development, to advance mineral extraction technology so that a stable domestic minerals industry can exist. Complete reliance on any one of these ways as the total solution could be disastrous. Logically, an optimum balance must be sought. Certainly, the Bureau of Mines cannot prescribe what this optimum balance should be. Our role is to work with industry and universities to assure that we aren't deficient in technology to make use of solutions 1 and 3--discover new occurrences, and continuously upgrade extraction technology. This, in effect, is the important relationship that exists among mineral economics, mining systems, and mining research. Only through a united team effort among all those involved in solving the Nation's minerals problem--industry (both large and small), educators, and Government--will our goals be attained.

How do we in the Bureau meet our responsibility? In carrying out our responsibility what is our relationship to industry and academic community? Before giving you our answers to these questions we want to convey our optimism for the continuance of a viable domestic mining industry totally responsive to environmental constraints and socio-economic considerations. Congress has recognized the need for basic mining research and now appears willing to provide adequate funding to carry on meaningful programs to provide solutions to health, safety, and environmental mining problems.

Importance of Mining Technology

As you undoubtedly know, mining is an inexact science and minerals are where you find them. Nature fixes most of the conditions associated with any given deposit. Nonetheless, it behooves us to do all we can to understand the conditions under which mining will take place. Only through such

understanding can we ultimately optimize the technology to the extent that minerals can be extracted from the earth in the most economical way with due consideration given to the health and safety of the people involved in the process and with minimal disruption or disturbance of the environment.

The importance of having adequate technology can be visualized by the "wheel" of progress depicted in Figure 1.

Mining technology is shown as making up the spokes of the wheel. If a technology spoke is not adequate, then the wheel will become distorted. The wheel can move to its economic goal if a few spokes are weak or are even broken. But if too many spokes are broken, the wheel will eventually stop.

Graphically a wheel represents the entire operation of a small, independent mining company. Larger mining companies would have several such wheels linked together. A small operation goes through the cycle of selling concentrates to a smelter or possibly selling mine rock to a mill for further processing. A large corporation has the same wheel for mining but adds another for the metallurgical process and another for a metal fabrication plant.

If the mining wheel does not function too efficiently at a given time, deleterious economic consequences can be absorbed within limits by large corporations but for a small mine operator any malfunction has to be corrected rapidly or the operation is in danger of closing.

The mining wheel as used here emphasizes the need for providing new technology to meet the changing demands of health, safety, and environmental considerations. The basic role of the Bureau is to supplement industry and university efforts to improve mining technology.

Bureau of Mines Mining Research Program

We wish to point out that the Bureau is not an ivory-towered research organization secluded in its research centers. We have competent and dedicated people available for your consultation. These people are vitally interested in all mining problems. We don't intend to compete with private consultants; rather, our research people should be looked upon as specialists who can, and do, advise on the state-of-the-art in mining technology. Where problems arise in a given mine which are representative of problems in a large segment of the industry and fall in areas where active research is being conducted, we can send personnel in to help on fairly short notice.

Beyond this, we will be constantly seeking the advice of the industry relative to our long-range research planning. It is our intent to work on the real problems in the industry. What better place is there to look for these problem areas than in industry itself?

Only a brief summary of our research activities can be provided here because of a time limitation. For simplicity, our program will be described by covering research activities carried on at each of our centers.

A. Denver - Mine Systems Engineering Group

First prerequisite for an efficient design of a mining operation is a model, which characterizes as accurately and precisely as possible those

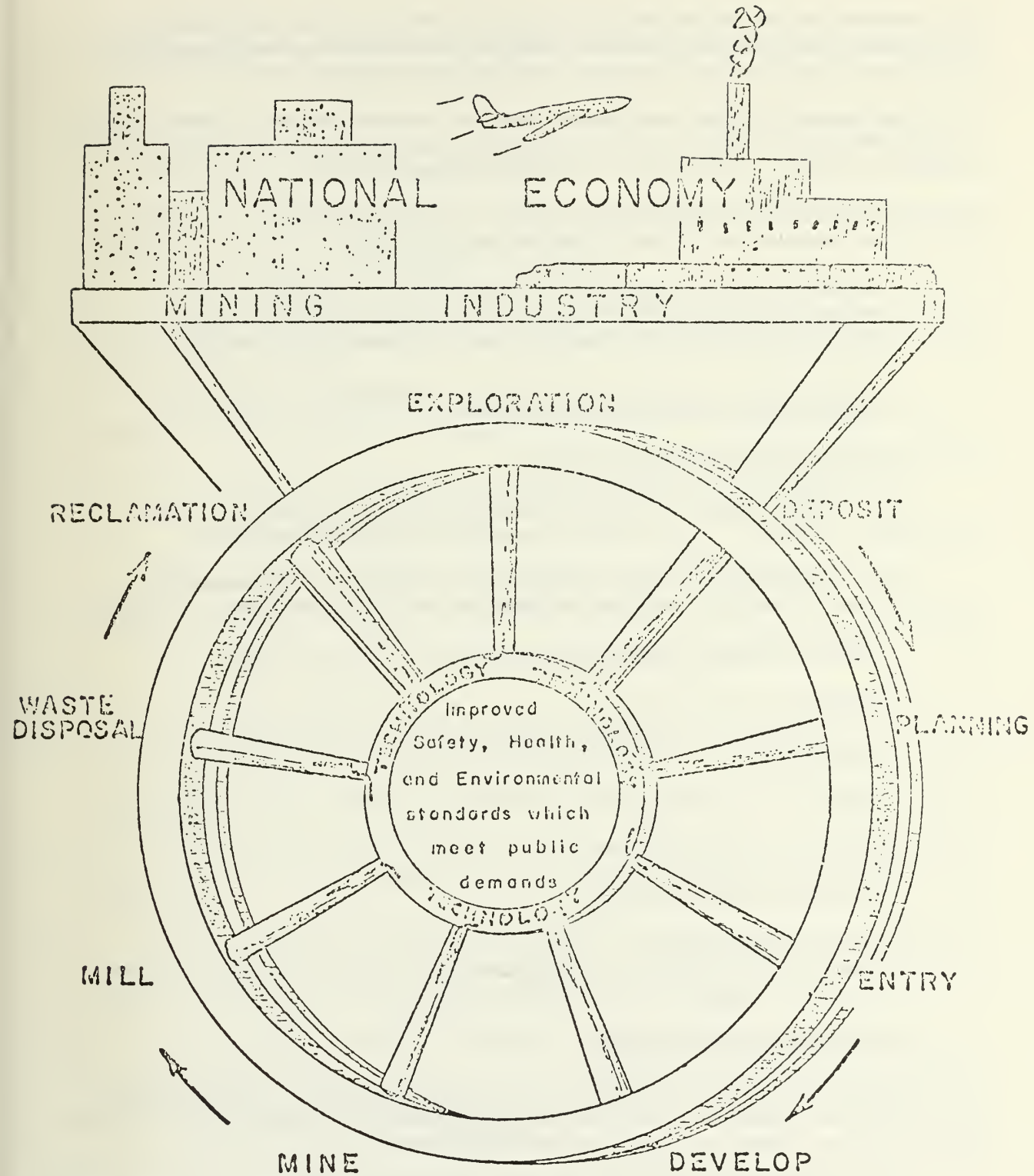
NATIONAL ECONOMY
MINING INDUSTRY
EXPLORATION
DEPOSIT
PLANNING
ENTRY
DEVELOP
MINE
MILL
WASTE DISPOSAL
RECLAMATION
Improved Safety, Health, and Environmental standards which meet public demands

FIGURE 1

features of the mineral deposit that will limit or affect the operation of the mining system. Factors to be considered include ore body geometry, structure, distribution of mineralization, rock physics, etc.

Development of improved techniques for delineating and characterizing mineral deposits must be a major element of any mine systems engineering research program. The Denver program includes work on:

- adaptation of statistical correlational techniques for analysis of sampling and other types of geologic data.
- investigation of geophysical delineation techniques such as seismic measurement of bedrock topography, borehole logging for structure and rock mass property determination, etc.
- development of Operations Research techniques for the design and control of mining operations.

B. Twin Cities Mining Research Center

The program ranges from basic research on brittle fracture (microstructure) in rock to such empirical studies as rock drillability.

This includes work on the conventional methods of rock breaking, drilling, and blasting, and also on some of the so-called exotic methods:

- thermal methods (thermal properties)
- flame jet
- plasma jet
- laser
- dielectric and induction
- hydraulic (low pressures)
- chemical softening
- big hole boring

C. Denver Mining Research Center

Carried on are basic studies of rock mass structural characteristics, properties and behavior as related to development of engineering techniques for structural design of specific mining systems.

A major emphasis is placed on work developing techniques for measurement of rock mass characteristics and properties. Examples are the work done on correlating seismic energy absorption characteristics and rock quality. Another example is the work on basic properties and use of microseisms.

An important element of this program is the development of numerical methods for structural analysis of mining operations.

Conventional rock mechanics studies cover design of development openings in block caving mines. These studies have been in progress for some time and are nearing completion.

Design of longwall operations in coal mines is also under study.

D. Pittsburgh Mining Research Center

Prior to 1964 the PMRC was a coal mining research center. It carried on small programs in hydraulic coal mining, hydraulic transport, and water infusion of coalbeds for control of methane.

Recent integration with minerals and metals mining research activities added responsibilities in the functional areas of materials handling and environmental control.

At present, materials handling is a small program but it will be expanded in three principal areas:

(a) definition of properties of mined mineral particles and aggregates and flow mechanisms involved in their loading and transport.

(b) computer simulation of materials handling system components and the systems themselves.

(c) demonstration of lab-scale hydraulic transports of mined material.

The environmental control program is primarily concerned with methane, dust, and water, all three principally related to coal mining.

Water control research is aimed at the problems of acid drainage from coal mines.

Dust research is related to the coal dust pneumoconiosis problem in coal mines.

Methane research is by far the biggest element of the environmental control research program. It includes not only the basic research but also systems development. Work presently underway includes:

. origin and structural controls of methane concentration in coalbeds.

. mechanics of transmission of methane through coalbeds and emission into mine workings.

. development of methods for drainage of gas in advance of mining and during mining, and of techniques for blocking or control of emission of methane into mine workings.

. ventilation research to assist in methane and dust control.

E. Pittsburgh - Safety Research Center

This is our newest Mining Research Center.

Safety is, of course, an important objective of all the mining research laboratories, but the overriding importance of health and safety in the Bureau of Mines mission dictates a center whose prime responsibility is health and safety. Furthermore, many aspects of mine safety are related to the total mining system so health and safety is considered to be an important part of the Systems Engineering research program.

The Safety Research Center combines many of the functions of the former Explosives Research Center and the Health and Safety Research and Testing Center.

Present plans are for the principal programs at the center to be in four major areas--two of them continuations of work done by one or the other of the two former centers and two of them new:

. explosives, explosions, and fire.

. basic studies of the chemistry and physics of mine dusts, both respirable and explosive.

. man-machine-environment relationships - human engineering.

. respirators - work for Air Force, Coast Guard, Viet Nam tunnels.

The Bureau's testing of mining equipment and accessories for permissibility is conducted by its Health and Safety activity, but in close cooperation with the Mining Research activity.

F. Spokane Mining Research Center

This center carries on basic studies of new materials and concepts for underground support to development of improved engineering techniques for better utilization of conventional support systems.

An important element of the Spokane program is concerned with backfilling of underground openings. This work so far has been concerned with hydraulic backfill, using mill tailings.

Research is underway on the design of a mill tailings dam and other types of surface waste embankments.

Just begun is a major effort on chemical stabilization of rock. Some of you may recall the work the Bureau did a few years ago on "rock gluing" using epoxies. Present work involves looking at polymers for in situ stabilization of rock. These studies are being done in cooperation with AEC, Brookhaven National Laboratory, and several other contractors.

We are also looking at concrete, including precast, cast-in-place, shotcrete, and polymer-impregnated concrete. The objective is to improve the properties of artifical structures.

In addition to the six field research centers, the Washington activity is comprised of three divisions, Mining Research, Health and Safety Research, and Environment. The first two divisions essentially do long-range planning and correlate research work in the field research centers. The Division of Environment is the focal point within the Bureau for action, research and study programs, and projects oriented to the resolution of environmental

problems associated with mining and the related mineral processing industries.

Through application of its various authorities, the Division contracts for and makes grants to State and local authorities for corrective projects, and for studies and demonstrations that can develop techniques of mining and mine processing that can assure availability of essential fuel and mineral resources with the maintenance of quality environments in mine areas.

Plans for the Future

As indicated earlier the Bureau is currently undergoing rapid growth in its mining research effort. The primary objective of that new growth will be improved health and safety. Present highest priority areas for the expanded programs are respirable dust and methane in coal mines. Other areas to be the subject of accelerated research are ground control, haulage and materials handling, radon daughters, noise, ergonomics, and lighting.

Though past Bureau research has been mostly in house, new growth will be primarily in outside contract research. This course is being taken for a number of reasons:

(1) to take advantage of the capability that presently exists outside the Government in order to get the job done as rapidly as possible.

(2) to strengthen mineral schools.

(3) to develop additional research and engineering capability outside the Government.

Mining technology is on the threshold of a new era of advancement. The mining fraternity in general is faced with unprecedented challenges. It will be called on to produce ever-increasing amounts of mineral raw materials, at higher production rates, from deposits of declining quality that will become increasingly difficult to mine. At the same time mining operations will be expected to preserve the quality of the environment and improve the health and safety of the miner. Technology will have to advance, and at a much more rapid rate than in the past. The probability for attaining this required rapid rate of improvement, through research, is high. Prospects for increased support of research by both industry and Government are good. The 1970's look exciting, and I am looking forward to them.

I extend an invitation to all to visit our research centers whenever you can and see what our people are doing. We welcome your interest and solicit your help.

ADVANCES IN TECHNIQUES FOR HARD-ROCK MINERAL EXPLORATION

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Amax Exploration, Inc.
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Changes in methods begin with ideas and the changes in mineral exploration, particularly in the last 30 years, are no exception. Before discussing new techniques in "hard-rock" mineral exploration, I would like to comment briefly on some of the conditions and ideas which are forcing these changes.

The old-time prospector's principal tools, in his search for mineral deposits, were his eyes and his gold pan. The presence of some evidence of previous work in every mineralized area in the U. S. which was of interest to companies I have worked for, is mute testimony to the ability of old-time prospectors to find and recognize evidence of mineralization at the surface even in places where the rock at surface contained only traces of economic minerals.

There are still places in the world, which are sufficiently untouched by modern mineral exploration, where it is possible to quickly recognize a prospect of interest by a simple surface examination. However, lands in the 48 conterminous states of the U. S. have been subjected to so much highly competitive prospecting in the last 100 years that most exploration geologists I know feel there is little liklihood of finding a new, obviously-good, exploration target at the surface within their limits.

Today, the combination of greatly increased demand for minerals and increasing competition, particularly in the U. S., is forcing us to continually re-examine prospects looked at by others and even by members of our own organization. However, it is fruitless to re-examine prospects or cover the same ground unless new information has been developed on the prospect or the re-examinations are made with new concepts in mind or new tools are used to generate new information.

It follows then, that people engaged in mineral exploration, particularly in the U. S., must be sufficiently versed in geology, geochemistry, geophysics and mineral economics to understand the interrelationship of all these factors in order to plan and execute imaginative and effective exploration programs.

Modern exploration can still be considered under the headings of two fundamental questions: "where should we explore?" and, "what methods should we use?"

Where to Explore

The geological concepts which have resulted in changes in approach to the question, "where should we explore?" have come from research on fundamental questions, much of it done by people associated with the academic community or the public sector (such as geological surveys). However, the private, profit-oriented sector of our society has also contributed much valuable information from research, particularly on major

deposits being mined. It is interesting to note that some of our best laboratories are the major deposits and even though some of these have been the subject of geological investigations for 50 years or more, new and valuable information is still being found. Useful research spans the range from global tectonics to detailed work on individual ore deposits.

It is not enough to point to an area in the world and say, "We should do some exploration work in this region because it is a large area, has been ignored by our competitors and no major mines have been found in it." Instead it is now necessary to consider global tectonics, igneous history, metamorphic history and metallogenic provinces, among other things, to decide which regions offer the best opportunities for successful exploration. However, so-called, "fishing expeditions" are sometimes necessary to obtain sufficient basic information to justify a major regional exploration program.

No matter where exploration is undertaken, it must be predicated on good working hypotheses which suggest that there is a reasonable possibility of finding acceptable ore deposits in that region. Good geological information from maps and reports is necessary as a foundation for good working hypotheses in exploration.

I believe it is fair to say that the research which has produced evidence of sea floor spreading and much better information on major structures has had a significant effect on geological thinking, including ideas about genesis and regional localization of ore deposits.

Research in the oceans has produced other discoveries of major importance such as concentrations of phosphate nodules and concentrations of copper, nickel and cobalt-rich nodules on the ocean floor and significant amounts of copper in sediments in the bottom of the Red Sea. The Red Sea discovery may provide us with important clues about the origin of some stratabound copper deposits which, in turn, could lead to new discoveries of major importance.

It is a statistical fact that most of the copper being produced today comes from igneous-associated deposits that were formed in Early to Middle Tertiary time. The reasons for this fact have been debated; but, as yet, not clearly established. Nevertheless, it is obvious that in order to maximize chances for discovery of a major copper deposit, the major effort should be in those belts which are marked by Tertiary igneous activity in a copper metallogenic province. However, good ore deposits can be missed by looking for just one specific type of deposit to the exclusion of other types. For example, in the past, some companies have not been interested in contact metamorphic type copper prospects - largely because that type historically and statistically did not include any major copper deposits. However, in recent years this situation has changed, because some people and organizations were willing to discount this point and judge a prospect worthy of exploration on the basis of permissive geometry and positive geological indications. The discoveries in recent years of major copper deposits associated with skarn minerals should provide ample evidence that statistics can be misleading. These facts further point out that each prospect must be judged on the basis of its own merits, without undue prejudice because of origin or type.

Regardless of any technical aspects, the one overriding objective of any mineral exploration program is the discovery of viable mineral deposits. Success can be best ensured by tailoring a program for any given commodity to the most favorable characteristics; but, at the same time, it is well to keep

in mind that geology and mineral exploration are far from an exact science, therefore other possibilities should not be excluded.

The beryllium industry provides a good example in the changing of ideas about where to look. Until recently, pegmatites were the source of almost all the beryllium ore produced. According to one line of reasoning, the Spor's Mtn. area in Utah would not have been considered a good area in which to prospect for beryllium ore because pegmatites are not present there. However, what may be the world's largest beryllium reserve, present as extremely fine-grained bertrandite in rhyolite tuffs, was discovered in the 1950's because someone was curious about the composition of nodules found there. Beryllium oxide is now being produced from the deposits. This new source also involves a change in technology from processing relatively high grade concentrates of beryl (usually obtained by hand-sorting) to making a chemical concentrate by hydrometallurgical processing of the raw ore.

In a similar manner, accent on exploration for niobium has shifted from small, high-grade columbite deposits, again commonly found in pegmatites, to large-tonnage deposits of pyrochlore in carbonatites.

To a certain extent, where we look for ore is determined by what we consider an acceptable deposit. Not so many years ago copper deposits averaging around 0.6% were considered too low grade to mine. Changes in technology, such as bigger and better earth moving equipment, coupled with higher prices, have made it possible to mine large copper deposits at even lower grades.

Geological concepts are of great importance even when a specific target has been found. For example, a common idea held by prospectors, a generation or more ago, was that mineralization should be better with depth. This idea was probably the result of observations in deposits where values had been leached from the weathered zone; but, unfortunately, seems to have been generalized beyond the surface weathered zone. Ultimately, it cannot be true for any deposit and often is not true even for limited depths. For example, low grade porphyry-type mineralization, at or near surface, may be in one of three general positions in an idealized deposit. It may be the sub-ore grade material above an ore deposit or, secondly, in the low-grade roots below an ore body that has been eroded away or, thirdly, in the most favorable zone to be expected in the prospect. In the first instance, a worthwhile target can be postulated, but detailed investigations of the other two situations would be a waste of money. Therefore, a correct answer to the questions of relative position of exposed mineralization is of vital importance.

It is apparent that in the future, where we look for minerals will be increasingly influenced by new concepts in geology, new and better information about the occurrences of minerals of possible economic significance, improved knowledge of the nature of specific types of ore deposits and changes in technology in mining and recovery of values. All of which will change our ideas about what constitutes an acceptable target.

Up to this point, political considerations have been left out of answers to the question, "where should we explore?" Exploration efforts are not attempted in many countries because the political-economic conditions either preclude the possibility or are so adverse as to make it unwise. However, these regions should not be totally ignored; because, whatever their present political condition, some of them contain areas highly

favorable for the occurrence of significant mineral deposits. The technical favorability of some sections of these countries will be eventually recognized where it has not been already. Eventually these favorable belts will be explored either by private industry or by governmental agencies. As a result, ore deposits will be found and brought into production. The new production will have its appropriate impact on the world supply-demand balance for each given commodity...probably no matter which side of the iron curtain it is on. For major companies, some knowledge of the potential of the politically and/or economically unfavorable countries could be useful either to anticipate major new sources of any given commodity or to be ready to take advantage of a favorable change in the political-economic situation when such change occurs.

The almost universal concern for preserving or improving our environment has added a new facet to mineral exploration. In order to minimize disruption of the surface in our exploration activities, we should avoid the use of bulldozers or similar equipment where possible and rely more on the use of more sophisticated exploration tools. People or organizations that unnecessarily disrupt the surface in mineral exploration risk bringing public wrath indiscriminately on all engaged in exploration. In the very understandable public concern about our environment, there is danger that legislation may be passed which will stifle incentive for exploration and add costs not related to finding or developing ore reserves or reclamation of land after exploration or mining activities. Unnecessary costs further disenfranchise the poor people in our country as far as their ability to buy consumer goods is concerned. Furthermore, unnecessary costs tend to reduce ore reserves by increasing the cut-off grade required for profitable operations.

Geological concepts, modified by political-economic conditions, largely determine the selection of major regions for exploration and greatly influence the selection of methods used in the field.

Field Exploration Methods

Under field exploration methods, I will discuss only the methods used to find specific targets for testing by drilling or some other means of checking extent of mineralization in three dimensions. Diamond, rotary and churn drilling are familiar to most people and are most commonly used for testing specific prospects in three dimensions, therefore will not be discussed.

The methods used in exploration, aside from basic geology, can be broadly classified as Geochemical or Geophysical, depending upon whether they are based on chemical or physical characteristics of the deposits sought. However, there are some which involve both or other disciplines such as Geobotany and Isotope work. The methods are discussed according to these general classifications though they may not necessarily be used in that order in an exploration program.

New and sophisticated methods of exploration may be costly; therefore, it is important to have a good understanding of the different ways an ore deposit may have formed and select the methods which are appropriate for the type of ore deposit sought under the physical conditions present. Even though some of these tools for exploration are costly; if they are well used, they can save many times their cost in better planning of a drilling program or, in some cases, by eliminating the need to drill.

It is worth remembering that almost every new method for exploration has been considered better at the outset than it turned out to be when its

limitations became apparent. However, any method is more effective when its limitations are known and it is properly used.

Geochemistry

Geochemical methods of all types are becoming increasingly important as a tool in exploration programs from regional reconnaissance to specific property investigations.

Commonly stream sediments, water, soils and rocks are sampled and analyzed for common economic metals. The material analyzed from stream sediment and soil samples is most commonly the -80 mesh fraction, though some groups use the -35 mesh fraction. Soil samples may be taken in the A, B, or C horizons according to which available horizon is most useful for evaluation of a prospect. However, it is advisable to take samples from the same soil horizon at any given prospect in order to minimize variables. The pH of soil and water samples is commonly determined and used as a valuable aid for interpreting the results. Rock samples are commonly composite chip samples carefully taken to be representative of the rock within a limited radius of a grid point. For best results, it is advisable to avoid including lichen covered rock or rock heavily coated with iron or manganese oxides.

Improved laboratory methods and equipment, such as atomic absorption, have made it possible to obtain reasonably reproducible results in the low parts per million range for most common metals. These results are most commonly used as direct pathfinders to find prospects containing the reported metal.

A new technique, which is now possible with reliable results, is to use metal ratios as demonstrated by the U.S.G.S. In their recent work in the Coeur d'Alene District, approximately 30 elements were determined in each of almost 6000 samples. The data was fed into a computer and used to produce many different ratio maps. This technique has produced some interesting results and is considered an effective exploration tool. The Zn/Cd ratio is one of the more interesting ratios in this district. Less common metals can be used in this manner as pathfinders for common metals.

New techniques in geochemistry must include discussion of the use of mercury as a pathfinder for other metals, as mercury has become an accepted geochemical tool in the past ten years. Mercury is commonly determined in soil and rock samples, but considerable experimental work has been done on determination of mercury from air exhausted from the interstitial spaces in soil. In another approach, the U.S.G.S. has used small planes to check concentrations of mercury in air. The technique is to mount a device on the plane which funnels air through a silver screen. The silver collects mercury from the air by amalgamation. The mercury determination is made by heating the screen to drive off the mercury in a regular mercury detection unit and reading the results. The mercury content of the air is calculated according to a formula which takes into account the amount of air that passed through the screen. The U.S.G.S. reports this method will indicate mining districts. It is too broad scale to be used for more definitive work and suffers the problems of variables such as moisture conditions, wind, barometric pressure changes, etc.

Mercury geochemical methods suffer several handicaps. One is that organic matter in samples tends to produce spurious results in some detecting instruments. Another is that mercury tends to sublimate from some samples after they are collected, also it may be partially vaporized when rock samples are crushed and pulverized. It appears that mercury can be a useful tool in geochemical prospecting, but possibly will be most useful in the search for ore deposits in pediment areas or other areas where the ore deposit is obscured by post mineral cover. However, because of the problems in using mercury as a pathfinder element for other metals, some early enthusiasts have changed their position and urge careful consideration of the conditions present to see if other pathfinders can do the job better.

Trace element assemblages, which are found as halos around certain types of ore deposits, can assist the geologist in deciding whether any given altered zone offers promise for the metal sought. This is an application of information developed by fundamental research, done largely in the quest for knowledge alone, by men associated with our universities, colleges and Federal Government.

For those of you interested in exotic methods of geochemical prospecting, Dr. Harry Warren of the University of British Columbia has reported on a method in which uses the metal content of livers from trout caught in lakes. At first, it sounds like a tongue-in-cheek approach, but it is a straightforward scientific approach taken primarily to determine background levels of various metals so that the true extent of pollution could be established. The method relies on the fact that trout feed, in part, on organic matter which naturally concentrates metals from the water. Because this is a year-round process, the seasonal variations in metal content of the waters and the variations in metal content from one part of the lake to another tend to be eliminated. The study indicated anomalously high metal values in several lakes in British Columbia around which there is yet no mining activity and thereby further established the fact of pollution by natural causes. It also shows that this method can be used for mineral exploration in appropriate situations. I expect that it will be easy to recruit men to undertake geochemical surveys requiring trout livers for determination of metal values.

Some organizations have tried to indicate major areas of interest by use of computers to contour results from a relatively small number of carefully collected samples. The objective of these methods is to indicate the major areas of possible interest quickly and with considerably fewer samples than are ordinarily taken in a regional reconnaissance type program. As it now stands, the efficacy of this approach is being debated.

Geochemistry has truly come into its own in the past fifteen years. It has passed through the period of over-promotion when some enthusiasts were saying in effect, "just give us some good husky high school students and we will find the ore deposits for you...or, geologists are not needed to find ore deposits". Just as in geophysics, it is apparent that geochemical methods have their limitations in exploration; but, as we have learned more about the limitations, we have learned how to use them more effectively. Much more research should be done to better understand the conditions under which metals move chemically in the weathering zone, such as the conditions which will shift the stability field for any given metal. As our knowledge of geochemistry increases, so will its usefulness for mineral exploration.

Geobotany

Geobotany is a field very closely allied to geochemistry. There have been attempts to use geobotany in mineral exploration for many years with varying degrees of success. Some of the most successful use of geobotany has been in Africa where areas have been traversed for a plant now well established as a copper indicator. Monica Cole of Bedford College in London reports that in some recent work done in Southwest Africa, copper was found in bedrock under every area in which this plant was found.

Isotopes

Isotope studies are in part chemistry and in part physics. Nuclear research can be credited with our improved knowledge and understanding of isotopes of various elements. As a result, we now know that pyrite in syngenetic deposits tends to be biogenically enriched in S32. Studies are being made of the relative abundance of isotopes of carbon, oxygen and sulfur in efforts to determine whether ore deposits are syngenetic or hydrothermal in origin or some modification of these origins.

Some studies on lead isotopes in the mid-continent region by Pierce, Antweiler and Cannon with the U.S.G.S. and Angino, Goebel and Waugh with the Kansas State Geological Survey suggests that productive districts are characterized by "J" lead types which are named for the Joplin district in Missouri. In the Joplin district, the lead 206:207 ratios are near 1:40. Accordingly, this may be a useful tool to limit the area of possible interest for more intensive exploration for anyone seeking Mississippi Valley type deposits of lead-zinc in the mid-continent region.

Age dates obtained by K-A or Sr-Rb determinations on rock and vein minerals are being used increasingly to test whether the deposit was formed in one of the more favorable periods for mineralization or not. It is a matter of record that most of the copper produced from porphyry copper deposits is from deposits formed in the Tertiary either 50 to 65 million years ago or 30 to 40 million years ago. Likewise there are favored time periods for the major molybdenum deposits and nickel deposits.

Another use of K-A age dates is to determine whether sericite from an altered zone in an intrusive rock is significantly younger than the host intrusive. If so, it permits hypothesizing the presence of an unexposed mineralizer intrusive at depth under the altered zone and a possible target for deep exploration.

Geophysics

Geophysical methods have been in use for centuries if we consider the use of compass needle deflection to find magnetite deposits. However, the more modern techniques which we usually think of under the term geophysics are a product of this century and mostly the last 40 years. The most important physical properties now measured as an aid to geological interpretation are magnetic susceptibility, resistivity, density, radioactivity, elasticity and chargeability.

The old standby ground geophysical methods such as magnetic, seismic, gravity and self potential have been improved and their use expanded.

Seismic and gravity methods were once almost the exclusive hallmark of petroleum exploration, but now both are used in efforts to determine depth to bedrock in pediment areas where exploration for base metals is considered. Most of us are familiar with the shot holes and large recording trucks used by petroleum companies for seismic exploration. However a very small unit is now available which uses a sledge hammer to transmit the shock into the ground. It is reportedly useful in determining depth to bedrock within 100 ft. of surface. Gravity surveys are also used to discriminate between EM responses obtained from massive sulfide deposits and other conductors.

The magnetometer has been adapted to airborne work and improved; sensitivities of one gamma or better can be obtained. Systems are now being flown which utilize two very sensitive magnetometers flown at the same time from the same aircraft to obtain either vertical or horizontal gradients. The results are recorded digitally on tape for computer treatment. Several consulting geophysical companies now offer services which treat the recorded information in a computer to eliminate regional gradients and high frequency effects caused by near surface features. The residual is then attributable to deeper sources. This technique should prove increasingly useful in attempts to geophysically "see through" post mineral cover. Magnetometer surveys in rough terrain are now commonly made from helicopters which can contour-fly the terrain at constant ground clearance to eliminate much of the terrain effect which is obtained in fixed-altitude surveys. Quick direct plotting of these results will show features of possible interest which can only be developed from the fixed altitude surveys by much time-consuming work.

Electromagnetic methods have been used successfully both on the ground and from the air for many years. These methods employ a transmitter coil which puts out an audio frequency E M signal and a receiver which registers the variations in signal strength due to differences in sub-surface conductivity. They are most effective in searching for massive sulfide deposits that lie within 300 ft. of surface and for that reason are used extensively in Eastern Canada where massive sulfide deposits are common and bedrock is commonly covered by lakes, muskeg or glacial drift. A recent modification called Turair uses ground E M power and helicopter mounted electronic pickup. It is expensive, but it is also reported to be more effective than either straight ground E M or airborne E M methods. Input is an airborne E M method that uses pulses of energy radiated from a large horizontal loop mounted on the aircraft and a receiving unit mounted in a trailing bird. The secondary electromagnetic field induced in a conductor is measured at a number of discrete times following each pulse.

AFMAG, short for audio frequency magnetic survey, uses natural electromagnetic fields generated by thunderstorms going on anywhere in the world. It is most commonly used in airborne surveys and is most useful in indicating major structures. It can be flown in conjunction with magnetometer and scintillometer.

K.E.M., radiophase and Deltair are systems which measure the variations in the very low frequency (V.L.F.) radio signals put out by U.S. Navy communication systems. These V.L.F. systems are similar to AFMAG in that they employ uniform primary fields. Faults, contacts and overburden edges as well as sulfides will generally respond; however depth penetration is reportedly not as good as for AFMAG.

Induced polarization, generally referred to as I.P., is a method which has come into prominence in the past 20 years. It is predominantly used on

the surface though it has been adapted for use in underground mines and drill holes. Chargeability of the rock is the basic feature involved in this method, though resistivity is measured. It operates on either the pulse method in which a charge is applied and the rate of decay of the charge is measured, or on an A. C. method in which the resistivity is measured at two different frequencies and frequency effects are calculated. I. P. is particularly useful in roughly mapping sulfide content to depths of about 1000 ft. However, the method does not distinguish between pyrite and the more valuable sulfides and may give anomalies which are due to clays or salts rather than sulfides. These uncertainties again emphasize the fact that the geology of any area in which geophysics or geochemistry is used must be known to best interpret the results. I. P. costs are about $450.00 per line mile.

In the last few years, a group has developed and tested a system of accoustical geophysics which has been applied in diamond drill holes and underground to indicate directions, orientations and approximate distance of structures at distances reportedly up to 400 ft. away from the transmitter. This method may provide useful assistance in more cheaply locating structures which may contain economic mineralization.

Radiometric surveys are made on the ground, from aircraft and in drill holes. Because of new developments which are embodied in airborne spectral scintillometers, radiation from uranium, thorium or potassium sources can be measured separately, which now makes radiometric surveys of use in regional mapping of rock types as well as a discriminating prospecting tool.

Remote sensing has become a popular term in the last few years, spurred by the emphasis on moon exploration. Photogeology using aerial photography fits into this classification even though it is a well established method used in mineral exploration long before the term "remote sensing" came into use. Aside from the obviously interesting bleached or discolored altered zones which show up on aerial photos, mineralized areas may be indicated by noting differences in vegetation. Vegetation may be inhibited over ore deposits for several reasons; for example, French geologists have noted that trees growing over bauxite deposits in the Kaw Mountains in French Guiana are inhibited because of soil sterility and improved drainage. Trees can also be inhibited because of lack of soil development over highly silicified, fractured hydrothermal deposits as can be found in the U. S.

The U.S.G.S. is doing some work aimed at detecting mineralized areas by the differences in the spectral signature of vegetation over ore deposits from that obtained over unmineralized areas. If successful, this technique could be a valuable tool for prospecting the many heavily vegetated areas of the earth.

Infra-red spectral scanning in the 8 to 13 micron wave length range offers promise for broad scale mapping of igneous rocks as responses range from 8.8 to 9 micron range from very acid rocks to 11.3 microns for very basic rocks such as dunite.

Thermal infra-red imagery is being studied by the U.S.G.S. for use in better defining faults and altered areas. In some airborne work, faults which carry relatively cool water show up as dark lines and some intensely hydrothermally altered zones show up as light colored areas.

Remote sensing includes side-looking radar which offers considerable promise in obtaining pictures of areas which are commonly obscured by cloud cover.

As yet, most of the exotic, remote-sensing techniques offer greatest promise in generalized, broad-scale mapping. However, this is a field which should be watched for developments which may be specifically applied in exploration programs.

Considerable research has been done in the past five years on heat flow. Much of this work has been done under grants from the National Science Foundation. It is too early to determine just how useful heat flow studies will be in long range exploration planning; however, it has been established that definite provinces with different heat flow characteristics are present.

One of the problems facing the use of geophysics is that the most methods which might indicate sulfides are effective to only relatively shallow depths on the order of 100 to 300 ft. I. P. may be effective to depths of about 1000 ft. which, geologically speaking, is very shallow as we hypothesize that most igneous-associated ore deposits were formed at depths of 1500 ft. or more. Another problem is lack of methods which can discriminate between conductors containing significant amounts of sulfides of valuable metals and other conductors such as pyrite, pyrrhotite or graphite.

General

It has been said that about 90% of all the geologists who ever obtained a degree from a college or university are still living. Many of these people are contributing to the rapidly increasing fund of knowledge in the general theoretical field and in specific applied areas. Both the theoretical and applied information must be watched for points which will improve our understanding of ore deposits and provide clues for specific exploration programs. Keeping up with this proliferation of new information is a problem which requires more time than any of us in mineral exploration have to spare. However, means must be devised to abstract and rapidly screen the available information for the items which are pertinent to any specific problem we are interested in, if we are to make effective use of the information and avoid unnecessarily duplicating others' efforts. The U.S.G.S. uses a computer information retrieval system called GIPSY, an abbreviation for General Information Processing System, which offers promise of rapid scan of information fed into it. Another group offers abstracting services of world-wide geologic literature on computer tape. Of course, the success of any information retrieval system will depend on how well key words are abstracted from each article and fed into the computer.

The proliferation of geologic information is illustrated in the estimate that 80,000 to 100,000 published and public papers dealing with some aspect of geology are currently appearing in a year. It is further estimated that this figure will double by 1980.

Industry experience and theoretical developments will push back the frontiers of geologic knowledge. Better knowledge and understanding of the genesis and nature of ore deposits coupled with increased demands from an increasing population will make it possible for us to successfully explore, with reason, to greater depths or through greater thicknesses of post-mineral cover.

It is abundantly clear that the exploration geologist of 1970 has more tools at his disposal than at any time in history; however, education and teamwork is required to use these tools. Though modern mineral exploration is a complex business, the best tools of all are a logical enquiring mind and an ability to effectively communicate ideas to others.

The exploration arm of the mineral industry recognizes the tremendous challenge to find the mineral reserves our society needs in the next 30 years. If incentive is not stifled, I am confident that we will meet that challenge.

PLANNING FOR SCARCITY

Hugh D. Galusha, Jr.
President
Federal Reserve Bank of Minneapolis

Three weeks ago we held the first of a series of seminars at the Federal Reserve Bank of Minneapolis to discuss different parts of our long-range planning effort that has been underway this last year. Quite appropriately this first seminar was devoted to an analysis of computer and communication technology. That discussion, like yours in this meeting, was concerned with the what, how, why, and who of storing, transferring and retrieving economic data. In these few minutes I'd like to try to apply some of the ideas developed in our study.

What data is easily answered. It is any data essential to the survival of man or his institutions. In one of its simpler forms, it is data about ownership of money claims. For example, instead of a check as the instrument of transfer of funds from A to B, there will be an electrical impulse to settle the transaction. With the per item cost of a credit card transaction at fifty cents, and that of a check at twenty cents, the seven and one-half cents per item cost of a direct fund transfer by electronic impulse is a powerful incentive.

In its most complex and sophisticated form, the data to be handled will be that which is produced ahead of the fact of its occurrence. I'm referring to simulation techniques and model building, both of which involve the assembly of historical data--that is, facts which have occurred--in equations based upon their relationships to each other, so that the results of different action alternatives in the future can be simulated without the pain of actual experience. This is not Buck Rogers speaking; most of the great corporations of the world now use these techniques, whether it be to simulate the performance of a plane or a rocket, or to match different levels of supply and demand for their products. In the public sector, economic modeling is becoming increasingly sophisticated, and while we cannot determine the alternatives for course correction as precisely and accurately as NASA can a space ship, we are making great strides.

Why is this important? It is because there now is a realization that actual experience is an extremely expensive teacher. And certainly it can no longer be our only teacher--in fact, if we continue to rely on actual experience as the best teacher in approaching many of our social and economic problems, experience might very well turn out to be the last teacher we have. This is because for many of these problems, there may be no second chance to try for another answer.

We have become a country of scarcities. Human talent, financial resources, and above all, time, are in short supply. There is simply not enough of any one of these to go around, and it makes little difference whether your example is the federal government, A T & T, the United Automobile Workers, or any of the fifty states. There is no U. S. institution that escapes the pinch. In fact, it is the one common assumption all projections for the next two decades agree upon.

The kind of prodigal waste that the expanding physical frontiers permitted over much of our history was possible only because the supply of human and natural resources seemed limitless. The price of failure was low because it was regarded as an individual concern.

But we have been pinched in two ways. At the same time the physical frontier was slipping away, the institutions of our society were becoming a great deal more complicated. The investment in money, talent and time to make them work has been exploding, whether they are organized for public or private purposes. The price of failure started to climb years ago; much slower has come the public awareness that it pays part of that price, but it, too, is now rapidly increasing. Whether it be Penn Central in the private sector, or Vietnam in the public sector, everyone loses when management fails and the losses cannot be made up.

How the data are to be handled has two aspects; solving the hardware problem, and the analysis of the cost/benefit factors. The first of these relates to the state of technology, which is very advanced, and which I do not understand at all. Sufficient perhaps to say that I have been convinced by a parade of experts from IBM, Honeywell, Control Data, the Bell Labs, and our own computer people that there exists the capability to do almost anything presently contemplated.

Costs of the hardware can be enormous, though, so evaluation of the cost/benefit ratios is really the more important of the two prongs of the "How" inquiry. What information is to be gathered, and the uses to be made of it after it is in hand, should be the determinants of the investment in the system. There are now existing computer and communication mixes to serve almost every kind of user.

The how problem is a people problem, and not a technological one. Matching the quality and skill of the computer technicians with the knowledge and motivation of the ultimate users of the data--the people who must say "go/no go" on the basis of the data--is an exceedingly difficult one, and is really where our energies have to be concentrated.

Who will use the data and for what purpose? I have offered one assumption with which few would quarrel--namely, that we have been and will continue to be an economy of scarcities. There might be less agreement, but I think it no less defensible, on the second assumption--which is, that there are only two directions possible for human institutions: up and down. There are no social and economic vacuums in which forward motion can be continued without effort, for friction operates as surely against governments and businesses as it does against matter. Not to consciously plan to move ahead toward defined objectives is to have unconsciously decided to fall behind.

There has to exist a set of objectives fairly well defined and agreed upon among the users of complex information systems. Unless these exist, marks on the wall and an abacus are enough. To design a computer system to serve conflicting objectives is not only impossible, but the attempt would be ruinously expensive. It is incumbent upon the leadership of the state, through whatever agency expressed, to decide what it wants to be informed about and for what reasons. Once defined, the matter of data gathering becomes an essential supportive function for the people who must make the decisions necessary to the attainment of the objectives.

I lived in Montana much of my life and, like the late John Steinbeck, I, too, continue to have a love affair with Montana. But I have never been conscious of a sense of direction in the state. For many years it was a luxury the state could afford because it really didn't matter, given the wealth and relatively free access to the natural resources with which the good Lord had endowed the state. But I sense things are not all that well in Montana now. While the state fared better than some of the other areas of the district in the 1970 census data, it still suffered from net out-migration, and I suspect there has been a net upward shift in the age distribution.

Further, the complaint is frequently voiced that Montana is a capital exporting state in addition to a talent exporting one. On the public side this is not true, because the balance of payments with the federal government is a plus, rather than a minus, but I suspect it is true on the private side. If it is, it is generally because the owners of that capital believe it can be more profitably employed elsewhere. In our economy, attempts to curb the mobility of capital, like attempts to curb the movement of people, have a dismal record. Ecological equilibrium, the "balance of nature," has its social and economic counterpart; and artifically upsetting that balance can be just as disastrous to an economy as some of the biologic evils we have committed in the name of progress. In this sense, out-migration of capital, like out-migration of people, is no problem but a solution to underemployment of both. As long as we continue to be a scarcity economy, human and financial resources will flow where they can be most profitably employed.

I should know better at this point than to continue, but the spirit of the early Christian martyrs is deep in the marrow of the Federal Reserve. It seems to me the central issue for Montanans, the quality of life for the individual Montanan, is almost totally obscured by the smoke of the rhetoric coming from the two extremes.

At one end are those who extoll the virtues of the simple life Rousseau wrote about. These people, with apologies to Mr. Rousseau, we can call the Noble Savages. It is their ambition to perfect a delivery system for care packages, appropriately filled with money, from the more populated areas, provided those delivering the packages don't stick around too long.

At the other extreme are the neo-colonials. These, in the tradition of those from the Mother Country everywhere, view the states as a source of raw materials to be extracted from the soil, air, and water, as quickly and efficiently as possible with the aid of the natives enlisted one way or another. In the old days, the blessings of civilization were the rewards for the natives; neo-colonials now talk a great deal about progress. There is a satisfying ring to both blessings and progress, nearly everyone feels they are joined in a noble undertaking, and it is easy to embarrass into silence those who timidly ask what the future social and economic costs will be to those left behind.

Random nongrowth, like random growth, is a luxury no one can afford. But we are stymied in varying degrees by the failure of information gathering and assimilation techniques in the public sector to keep up with the advancement of these techniques in the private sector. State and local government is the biggest business in Montana. The second, I suspect, is the federal government. Together, as I recall, they employ more people

than does agriculture in this state. There is little you can do about the federal government; there is a great deal you can do about state and local government. A definition of objectives and the tools to work with are starters.

Just one example. This session will be grappling with serious budgetary problems--perhaps more serious than any of the last decade. National economic policies forced you out of national money markets for much of the biennium, so I suspect the backlog of public projects has awesome proportions. It also caused a shortfall in income tax collections, I suspect. How can a legislator possibly measure the cost/benefit ratios in appropriation measures--the impact of tax proposals on the total economy of the state? The way since time immemorial in Montana has been to listen to various constituencies and their lobbyists, pitch the programs at what appears to be the middle, and then wait for experience to judge the wisdom of the decision. The power to tax is truly the power to destroy. How much better it would be to know within reasonable limits the objective impact of tax measures on different constituencies, and then tackle the political question in the full light of those facts. The Upper Midwest Research and Development Council, working with the University of Minnesota, and financed by a Ford Foundation grant, has been developing a computer program called RAFT to do just this. If they meet their scheduled targets, the Minnesota legislature this year will have access to an information system into which different patterns of taxation and rates could be plugged, and the consequences determined. At the heart of it are computer capacity and techniques of a high order.

Without these, and the will to use them, the kinds of computer programs being developed in different parts of the world, and designed to make all kinds of human institutions, public and private, work better, cannot be applied in Montana.

Coordination among the users will be an exceedingly difficult political problem. When I reflect upon the Ninth Federal Reserve District, it is easy to despair. With 13 percent of the continental land area of the United States, and only about 3 percent of its population--and that concentrated in a relatively few cities--the Upper Midwest too often looks like a collection of warring city states. Efforts to unite Sioux Falls and Rapid City, or Billings and Great Falls, to single out just two examples, in a common South Dakota or Montana cause often seem to have little more success than efforts to get Sparta and Athens together. Add to the inter-city rivalry counties, school districts and other political subdivisions, plus the array of institutions and agencies on the state level, and the obstacles may seem insurmountable. Yet there are successs stories and places where public recognition of common self-interest have united warring communities, interstate authorities, metropolitan councils, intrastate regional governments. These are examples to give us heart.

It certainly should be obvious there is not enough money and not enough talent to permit random expansion of computer facilities in this state or any other. Less obvious, but more fundamental, though, is the cost of the inevitable widening of the gap between the aspirations of the public for their government, and the capacity of that government to deliver.

I have talked excessively about the economic aspects of information systems. These may soon, for many information systems, be less important than the applications to education and health care. There is a real risk

in any talk about computer and communications technology that the speaker may end up simply reinforcing the universal fear in his audience that the individual human being no longer matters, and human judgment is obsolete. Nothing could be more wrong. Information systems exist only to enhance the capability of human judgment in human affairs.

The special interest of a world of scarcity is to assure the best use of what is available. A statement of goals, the systematic gathering of data, the development of plans of action; these steps have common purposes in public planning to make sure individuals are treated fairly and the delivery time of government programs is fast and efficient.

To an observer who has been infatuated with Montana all his life, the state is at some kind of a watershed today. Growth versus no growth; the shape and requirements of higher education; the costs and delivery of health care in the state; I sense a greater public awareness of fundamental issues in Montana than ever before in my lifetime, and a greater willingness to go behind the rhetoric of the ancient positions of politicians and power groups to the realities of now. The purpose of these sessions is to find better ways of exposing and measuring these realities in all their implications to better serve the public.

HISTORY OF DATA PROCESSING IN MONTANA

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Research Engineer
Montana State Highway Commission

The history behind the basic concepts of our data processing world of today began thousands of years ago. The first counting systems developed when man had to accurately determine the extent of his possessions, the size of his sheep herd, the volume of his stored grain, and his due for the tax collector. Numerical symbols are evident in 3,000-year-old Egyptian hieroglyphics. Early traders who crossed the Mediterranean or drove caravans over the deserts of the Near East into India and China counted with sand tables where stones were placed inside circles drawn in the sand. Each stone counted one and ten stones filled a circle.

Because it was still hard to tally the stones, a sort of decimal system eventually evolved, and various forms of this system spread throughout the ancient world. Gradually, sand tables and other cumbersome methods of tallying disappeared as Mediterranean traders developed the first computing machine called the "abacus," which is still used today in many parts of the world.

Other cultures developed systems based on different numerical representations. One of the most primitive systems used sticks and stones for counting. It is this system, the "binary system" or "base 2 system," that is used in the most powerful computers. Why? Because electricity can either flow when a switch is "on" or not flow when a switch is "off." A metallic memory is either magnetized when electricity is "on" or not magnetized when "off." These simple principles are the basis for all logic and counting in the most complex machines.

Though a Frenchman named Jacuard was the first to use punched cards in a machine to control the operation of a loom converting silk thread into cloth with many patterns in 1804, Dr. Herman Hollerith was the first to use punch cards as data records to be processed through machines. As head of the U.S. Census Bureau in 1890, he feared that an accurate count of U.S. population couldn't be made before 1900, because the 1880 census took nine years to total. He built a card punch, sorter and tabulator and completed the job in two years even though there had been a 25 percent increase in population in that decade.

The pioneer in data processing in Montana was the Montana Power Company, which installed its first punch card equipment in Butte in the fall of 1930. The equipment was used for gas and electricity billings, but in those days only numeric information could be processed, so an addressograph was used for names and addresses. Cards were punched with round holes in only 45 columns instead of today's standard of 80 and the machines processed at what seemed to be a fantastic rate of 25 cards per minute. Today, of course, 2,000 cards per minute is not unusual.

The early key punch machines were hand fed and the gang punches were set and locked by hand. Even though the machines would seem awkward to us, their use improved business accounting procedures and soon payrolls, general cost distribution and inventories were standardized to a machine system.

Of particular interest in the year 1936 was the installation by the Montana Power Company of an IBM 405 alphabetic-numeric accounting machine. The utility company was the first in the nation to install such advanced equipment. Names and addresses became part of the data processing operation.

Because of the capacity and efficiency of machine methods, Montana Power in 1938 centralized all of its accounting in the Butte office. The company continued to upgrade its operations, and in 1943, it was the first utility in the northwest to install an electronic calculator, a forerunner of the first operation computers.

In 1937, a year after the Anaconda Copper Mining Company installed four machines, the Montana State Highway Commission leased similar equipment for statistical work in the Planning Survey Division. By 1941, the Accounting Division took jurisdiction of the machines which handled payrolls and general accounting.

By 1938, Anaconda Copper had systemized its billing procedures for municipal water the company furnished to residents of Butte and Anaconda. Company management found, too, that the machines were valuable assets when payroll deductions came along with the advent of Social Security in 1937 and income tax in 1941. These deductions were not computed, but gang punched from a rate deck into the earning cards.

Other early users include the Unemployment Compensation Commission in 1939; the Welfare Department in 1945; Montana State University, 1946; Montana Physicians' Service, 1948; Midland National Bank of Billings and Montana Flour Mills in 1949. In the early 1950s, more banks, Buttrey's Foods, Yellowstone Park Company and wholesale drug companies controlled inventories, processed payrolls and did general accounting.

In 1958, the mathematics department at Montana State University in Bozeman, which was involved with complicated statistical problems, justified its need for and installed the first electronic computer in the state of Montana.

Back in 1937, out of Montana Howard H. Aiken, A Harvard University Ph.D. candidate in physics, had begun work on a machine that could automatically solve differential equations. The plans were so interesting that IBM sent three of its engineers to help him. In 1944, the Mark I was completed and the present day electronic computer was born. The Mark I was not a small baby; it weighed in at 5 tons and had 500 miles of wiring, was 51 feet long, 8 feet high and contained 3,300 electromagnetic relays. It could add two twenty-three digit numbers in three-tenths of a second or multiply the numbers together in about six seconds. Under automatic control of a paper-type program, it could produce intermediate and final answers to a problem on punched cards or on a print-out sheet.

In 1946, Drs. Mauchly and Eckert at the University of Pennsylvania built "Erica." Two years later, IBM built a selective sequence electronic calculator and four years later, Professor J. Von Neuman of Princeton built the "Maniac," while in the same year, Remington Rand Corporation came out with the "Univac." In 1952, IBM produced the 701 and thus started the trend of naming machines and systems by numbers.

The IBM 650, Montana State University's first computer, stored data on a rotating drum about one foot long and six inches in diameter that turned

12,000 revolutions per minute. Nearly 2,000 instructions could be coded on the drum surface in the form of magnetic spots. Data input was 250 cards per minute, and punched output was 125 cards per minute. There were no printing capabilities, so the output cards were carried to off-line equipment to print reports. The machine was built in two large 6 feet by 8 feet by 2 1/2 feet combinates, each weighing 3,000 pounds, and generated enough heat to warm a three bedroom home comfortably in the winter. Air conditioning was a must and the machine frequently failed if it became overly warm (about 100 degrees Fahrenheit).

Two other IBM 650's were installed in the state, one at the Highway Department in 1959 and one at the Forest Service in Missoula in 1962.

Second generation computers appeared in the state in 1961. The first, again, at Montana State University replaced its 650 computer. The Highway Commission rented two second generation machines, one with large storage capacity for engineering and statistical problems and one with excellent printing and report generating ability for accounting and G.V.W. tax work.

The first random access computer was installed in Buttrey's Foods in Great Falls in 1962. An inventory of all the company's food items was kept on disk files which were available for feed shipment, reordering, and inventory accounting monthly.

Banks in Montana are heavy computer users, but they have unique problems with equipment. Checks are not a standard size and handwriting cannot be read by machine. To overcome this problem, checks are pre-printed with bank numbers and the check amount is imprinted with machine readable characters after the check is cashed. The Federal Reserve Bank at Helena, as well as all the larger banks and many smaller ones, are using computers.

Today there are about sixty computers in the state working on business, banking, science, education and accounting problems. Many are large third generation systems which measure processing time in micro seconds and nano seconds and have storage capacities in the hundreds of thousands of digits.

There are four computer systems in state government here in Helena. Two are large all-purpose centers, the Central Data Processing Center in the Mitchell Building and one in the Highway Commission Building. Two are smaller special purpose machines at the State Liquor warehouse and the Department of Public Instruction.

The Central Data Processing Center helps all state agencies requesting service. The Center systematizes work, writes programs and processes data for over 40 different agencies. The State Board of Equalization, the Fish and Game Commission, Industrial Accident Board, Department of Administration, State Auditor, Welfare Department and Department of Institutions are some of the agencies who use the computer either daily or frequently. To process the large volume of work, the Department of Administration rents a model 40-IBM 360 with 128,000 bytes of internal storage and has on line two printer, four high density type drives and four disk drives. The disk drives hold as many as 100,000,000 digits of information which are instantly available to the system.

The Highway Commission has an equivalent machine for computing all design problems, cost accounting, inventories, statistical studies, truck registration, and gross vehicle weight taxes. One additional feature on the Highway Commission machine is an on-line plotter for roadway cross section and graphs.

In only twelve short years since the first computer was brought into the state, every citizen now benefits from computing capabilities. Travel reservations are made within minutes without error, food stores stock their shelves in proper amounts, banking facilities offer more service and state government is operated more efficiently. The next decade will in all probability see even more progress in data processing.

COMPUTING FACILITIES AT THE UNIVERSITY OF MONTANA

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Missoula, Montana

I want to discuss three topics: 1) the past and present status of computing at the University of Montana; 2) the present and future requirements for computing facilities at the University of Montana; and 3) the future computing facilities in light of these requirements.

The first signs of data processing appeared on the university campus in 1957 and consisted of some keypunches, a sorter, and a printer. They were specifically for administrative use. In 1963, part of the basement of the liberal arts building was remodeled to accommodate an IBM 1620 computer and associated types of equipment. This equipment was intended for use by the students and faculty and the entire cost of this operation was about $100,000, all of which was borne by grants and donations. In December of 1964, the administration augmented its equipment with a 1420 computer, then replaced this equipment with a 1401 computer which they presently have. There are thus two separate and distinct computer centers on the campus, each principally devoted to the work for which its equipment was originally acquired; however, there is a sharing of each facility.

The educational and research center services last year accommodated over 1300 students, each of whom used the facilities at least once, and most of whom used it several times. Such use was primarily for their assigned class work. Several faculty members also used the computer for their research. We have also provided computer service and training for our secondary and elementary school districts, which took the form of providing test scoring services, computer log and course work, etc. Also, the Forest Service and some businesses used our services after it was determined that they could not obtain such services elsewhere. It should be pointed out that because of the severe computing limitations of our computer, which is over 11 years old, many faculty and student projects were of necessity done elsewhere or not done at all. It is the policy of the center that all student use of this computer shall be done free of charge. In all universities, a computer should be considered as a laboratory device like a microscope, or other research equipment. Research and computer work funded by outside agencies is charged for at a fee determined by the center's operational costs. This policy has resulted in a bursting of computer use and a swamping of our present facilities. We have had to reject student computer problems because of our limited computer capabilities, and have even had to turn down paying customers.

The faculty and administration have decided to upgrade the present computer facilities in recognition of the tremendous impact that computers are having on education, especially university education. Such upgrading is long overdue for several reasons. We must prepare our students if they are to be in a competitively fair position with graduates of other institutions. Curricula in many places are changing drastically because of the computer, and this is especially true in a liberal arts university.

The engineering and science universities have gone through this revolution already, but we are just now entering it. Daily more effective techniques are being introduced into courses, and the techniques depend to a large extent on computer capabilities. In order to accommodate the changes, so as to better train our students, a much larger and more sophisticated computer system is required. We are a university, and one of our purposes is to search for new knowledge. In this search the computer has proved to be a most valuable and almost necessary tool in every scientific discipline. Both our senior and graduate students, along with our faculty, require such a tool in order to successfully follow out their research.

We are reaping the benefits of the misuse of technology in our pollution and environment problem; the real problem posed by the misuse of the computer is potentially far greater. Typical of this is the invasion of privacy through the use of data banks, the loss of democratic processes through applications of the computer to the electoral and legislative process, the centralization of information knowing that knowledge is power, and so on. Thus it is imperative that we come up with a means of preventing these problems that occur, while simultaneously looking for cures that are not worse than the sickness.

For the above and many other reasons, President Pantzer appointed a faculty committee to assess the future computer requirements of the university and to recommend the characteristics of the computer system that can most effectively and economically meet these requirements. The committee conducted a survey of all the faculty and many interested students, interviewed faculty at similar universities, read many professional journals, and consulted with numerous professionals. Armed with information, and assuming that student computer needs and service were paramount, the committee drew up a list of requirements: 1) The computer must have the capacity to allow several people to use it simultaneously and have it appear to each user that he alone is using the computer (timesharing). 2) The system must be reliable, that is it must have a proven track record. Both the computer hardware and software must work, because we do not have the engineering and science schools here which could help us out if the computer failed to work. 3) The system must provide reasonable computing power--as we are a liberal arts university, we do not anticipate extremely large computing problems. When these occur, provisions may be made to solve them elsewhere, chiefly on large machines which offer more computing per dollar; however, we do require that the larger computing capacity necessitated by some administrative problems be built into our computer. We also require that the computer be large enough so that if the computer is tied in with the state network, it does not degrade the service to be provided by such a network. Thus the system must be able to work effectively with the proposed state system. The maximum number of programming languages should be provided so the maximum number of people, particularly students, can easily use the computer. 4) The system must be easily and economically expandable.

With these requirements in mind, the committee drew up a set of specifications for requests and sent one to each of the computer vendors. After many months of reevaluation and negotiation, a decision was made to acquire a system. A proposal for a request for financial aid was sent to the National Science Foundation. As luck would have it, within that week, the National Science Foundation sent a letter to all university and college presidents, throughout the country, announcing that the foundation was no longer funding general computer systems for institutions of higher learning.

In spite of this, and because the need for much larger computing facilities on this campus is so great, the administration committed the university to acquire a larger computing system. The commitment will be met by reordering our internal priorities. Because the necessary aid will not be forthcoming, the manner in which the computer will be acquired must require the least initial financial commitment on the part of the university. This has dictated to us the kind of system we must start with. We eventually hope to expand the system so that it may accommodate administrative data processing and be adaptable enough to enter the statewide computer system or plan. In addition, we would like to better serve the communities and schools of western Montana. In spite of our financial restraints, we feel that we have a plan for computing which is both educationally and economically sound.

MONTANA'S STATE INFORMATION SYSTEM

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You might note if you look at your program most of those on the panel, with the exception of two, are involved with a data processing center. I am not involved with a data processing center nor do I direct one. I am involved with Montana's State Information System. I am a user of a data processing center, so any remarks I make should be considered from this perspective.

I am frequently asked the question, "What do you do?" and I say, "I am involved with setting up our State Information System." And the inevitable reply is, "Well, what is a state information system?" or, more explicitly, "What is Montana's State Information System?" State information systems do not fit any particular definition; they vary from state to state. Because they are new, they are in the development process. However, I might say that a state information system could be analogous to a corporate program planning control system or management system in industry. Such a system in industry will frequently supply information to the President or to upper management, to the Board of Directors on finances, production, scheduling, sales, or quality control. If we look at information systems as they exist in other states, we will find that there are no two alike. In most states, if they do exist and when they do have an information system, they are normally in the executive branch of state government and some of these are highly centralized information systems, for example in Hawaii. Hawaii has what is termed a statewide information system, or, as in the case of Pennsylvania, the PIMISS system (Pennsylvania Interagency Management Information Support System) is being designed and developed. Another kind of information system is a legislative information system. Some of you, I am sure, are familiar with Wyoming's progress in this area, and perhaps the state of Washington's progress; even Montana now has acquired a Legislative Information capability. There are even a few states involved with setting up judicial systems.

Where these information systems exist at the state level, there are many users beyond state government. Local government, the business community and private citizens are users, in addition to those which the systems primarily serve.

Let us now look at Montana's State Information System. It is a division of the State Department of Planning and Economic Development. It is one of five divisions, the others being the Planning Division, the Research Division, the Industrial Development Division, and the Administrative Division. Our Montana State Information System is a socio-economic information system. That is, it is primarily involved with the handling of socio-economic data, population data, etc. As an example, we are a Summary Tape Processing Center, an agency that has been assigned the responsibility of handling Census tapes relating to Census information on the state of Montana. Much of the socio-economic information is in a library that we have developed which houses most of the statistics relating to Montana, whether they be from a federal source, a state source, or a local source. We have developed a fairly

extensive library relating to statistical information and research reports on some segments of life in Montana.

In 1969, Montana's State Information System handled about 440 requests. Forty-six percent were for business, 34 percent for governments, 21 percent for students, 3.4 percent for families, a little over 2 percent for teachers, and almost 2 percent for libraries around the state. In 1970, we began to see a shift. By the first half of 1970 we had 500 requests, more than we had in the entire year of 1969. In 1970 the composition of the requests changed considerably; over 70 percent now were to the other divisions of the Department of Planning and Economic Development. The remaining 30 percent were to other governmental offices, state and local, industry, etc. Some of the particular types of data that we are involved with are specifically the 1970 Census. Montana was the first state in the United States to complete its enumeration of population statistics. We were the first state to release preliminary reports and advanced reports.

Another set of users of the State Information System are the City and County Planning Boards throughout the state. Some of these, including Billings, Missoula, and Great Falls, are contracting with us to provide information on their localities from the various counts on tape from the 1970 Census. We are working with Helena Model Cities in also providing information to them on the composition of the city of Helena, primarily from Census Data. We are working with the State Housing Study being conducted within the Planning Division of the Department. We are working with the State Comprehensive Health Plan which is under the Department of Health. We are working with our own Planning Division on a series of six tabulations to cut across all of the geographic levels of the state. We work with our Research Division and our Industrial Development Division on a relatively wide variety of data relating to their activities.

A large number of requests for information come from other state agencies. We receive calls daily from state agencies relating to data and its availability. The business community is a fairly large user. We are at this point in time receiving requests for information from a wide number of businesses in the state. The universities are also users, although on a relatively small scale.

Several observations which relate our activities to data processing problems in general are in order. First, state agencies and local governments use data for a great variety of purposes and much of the data are used in common by many of these agencies. As we've just discussed, population data, income data, financial data, and budget data are used by all agencies in common. Secondly, functional data processing organizations are growing rapidly in most states in the country. Many have grown so rapidly in data processing centers and people that there appears to be no way to get their organizations to talk or to communicate with each other. I might cite the example of the City of Los Angeles, which is building a criminal information system on the whole city. Two blocks away, the County Sheriff's Department, an equally large organization, isbuilding a criminal justice information system. They both cover virtually the same area, the County of Los Angeles. The redundancy growth rate is proportional to the growth of functional systems. Thirdly, the cost of data processing and systems in all states is increasing at an exponential rate.

Then, too, the right of individual privacy and confidentiality becomes a much more major issue with automation of records. I would like to cite

the example of the Search System. Search stands for a system for electronic analysis and retrieval of criminal histories. This system has been developed within the state of New York under the direction of Dr. Gallati. As was pointed out by Dr. Gallati, an information system of this sort has information on the subject's name, his place of birth, his sex, occupation, race, height, hair color, features, skin tone, identification marks, FBI number, Social Security number, operator's number, operator's license number, etc. It also contains information on the date, the arrest charge, whether the individual was subsequently released, and so on and on. A large volume of information on individuals is available through the Search System. However, what is of interest to note, is that there are RAP sheets available on perhaps as many as 8 percent of the total number of people in the United States, according to Dr. Gallati. Many of these records will stay there forever as the record is not thrown away, and many of these charges are carried with a person and by virtue of automation and putting it in a system means these data then become available nationally. The right to privacy and the security of these files nationally is a consideration.

Lastly, I would like to make the observation that each state must determine what kind of information it wants: whether the state is to continue in the development of individual functional information systems within each level of government and its inherent duplication, or whether we are to have unified information systems.

COMPUTING: MONTANA STATE UNIVERSITY

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The organization of the Montana State University computing center is based on serving four major areas: 1) instructional education--the students; 2) administrative data processing; 3) support of research on campus, both in computing sciences and in fields that are exterior to the computer itself; 4) service bureau. About 5 percent of our work is conducted for commercial firms, state or local government firms, but the jobs are completely unsolicited. One of our policies is that we will not knowingly compete with any Montana-based service bureaus.

Primarily, we should ask what the priorities are in making such services available. First and foremost are the students; beyond that the entire university; next, the community; then the county; then the state; and on down the hierarchy. We actually do have federal projects going, and branches of the federal government do use our services. If we reach the point of total saturation, however, then we will have to devote ourselves more and more to the university and will be forced into the position of turning down the commercial firms--the service bureau part of our organization. Finally, then we will have to rectify the proportion of research, data processing from the administrative side, and instruction and education. The growth curve in utilization is fantastic. In 1 1/2 years we have gone from 17 percent to an average of about 65 percent utilization. The estimate for this year is that we will probably average 75 percent if everybody was honest with his own predictions of personal, class, or other uses. I suspect that there were many things that were forgotten, and many plans that will come up that will push the utilization figure even higher. The maximum capacity of the plant as it exists now is probably about 85 to 90 percent utilization.

There is a variety of cooperating and noncooperating units on campus. Most of these, fortunately, are cooperating. Computing sciences is definitely a major cooperating unit. Surprisingly enough, the math department was not a cooperating unit before, but it is now. We cannot truthfully say at this stage that there is anyone who is noncooperating through his own volition. The only fields that are not using the computer on campus are music and art. Approximately 1,200 out of 8,000 students used the computer personally, to our knowledge in the last quarter. Since there are three school quarters in a year, and four years of college, this means that only 9 percent of the students on campus will not have direct contact with the computing system and with the computer. This I think is good, but of course I'm biased in favor of maximum student use.

We have an excellent working relationship with state government, for those departments with which we have any relationship at all. In particular, we have good communication with the Department of Administration and the Highway Department, none with the Liquor Board, none yet with Public Instruction, and unfortunately, none with some of the colleges around the state. The members of the University System itself are starting to get

together and cooperate. I'm worried about our relationship with public instruction, because we actually do service the high school in Bozeman, and have provided services to other high schools. We've been instrumental in trying to get high schools to participate with colleges on a timesharing basis, to train the schools in computing. The last relationship is with Doyle Saxby of Administrative Planning, the State Controller, and this has been a very good one. Doyle has spent more time than he really had available on us and on computing throughout the state, trying to coalesce and correlate the entire computing regime in the state. I do feel that he needs more help. We should have a coordinator of computing and communications below us. That is our biggest problem on campus--communication, and it's not new. Communicating through all facets of the state, right down to the public level. There has been a proposal made that MSU consider a computer cooperative extension.

I want to thank you state government people for the cooperation you've given us. I'd also like to thank you for 2/3 of our $500,000 budget per year. Our computing center is in far better financial state than the majority of those in the country, because we are not solely dependent on federal grants. Those that are solely dependent on federal grants are just about to quit.

SYSTEMS DESIGN AND PROGRAMMING PROBLEMS

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There are many areas in data processing where problems are encountered. The areas of greatest concern to many of us are systems design and programming. All aspects of data processing are dependent upon the quality of the products from these areas.

Let's look at some of the present problems and see why they are prevalent. Probably one of the most significant facts we must face is that in many cases salaries for professional employees are inadequate. These are the people who make the computers function! In the past this field has been noted for its number of "job hoppers." This has led to filling positions with unqualified personnel with a proportional reduction in the quality of work performed. Much time and money has been spent in hiring and training personnel until they are qualified to do satisfactory work. Then they have moved to another employer at a higher salary. This is false economy and a great deal is lost financially.

Standards for systems design and programming have been lacking or very generalized. Poorly designed and programmed systems have led to reinventing the wheel time after time. The inefficiencies here are obvious but the magnitude is not always apparent.

Another area is the lack of complete standard procedures defining the documentation requirements. This has led to poor documentation or no documentation at all.

Some of the problems which have developed are not fully recognized until years later when it is necessary to change the program or convert to a new computer system. It seems that enough time is never allotted for documentation. This is the most important aspect of systems design and programming and yet has had the lowest priority in many cases. The movement of personnel from one employer to another has emphasized the importance and high priority that must be given to proper documentation.

Many projects have been established without a detailed systems study. In many cases not enough lead time is allowed for a detailed study so that a completely workable system can be developed. Then too little time has been allotted for programming and properly checking out the completed system. The result is a poorly designed and programmed system which must be continually monitored for accuracy and completeness. In some cases programs have had to be rewritten or modified to properly perform the task required. Actually in retrospect a great deal of effort could have been saved if the time had been taken to properly design the system.

Many problems in system design and programming are compounded by the fact that adequate equipment is not available to do the job. But everyone knows that a computer can do anything! Users believe this to a large extent because computer vendors and data processing managers have oversold the computer capabilities. So a "make-do" situation arises, such as cramming a large data file into a small disk storage unit or using small

computers for very complex programs. This adds to the system design and programming problems so that a relatively simple program becomes complex and difficult. While this gets the job done, it doesn't allow using the full potential of the computer's capabilities.

Space would seem at first glance to be a minor problem, but data processing has been expanding very rapidly with large space requirements. Ordinarily the computer system ends up with the best space (which may be inadequate anyway) while the staff must utilize what remains. This may mean having six programmers in one room or they may be physically located some distance from the computer. System design and programming require adequate personnel space, as the thinking process demands it if productivity is to be expected.

What must we do to alleviate some of the problems we have had in System Design and Programming? Some solutions, such as stabilizing our personnel, are obvious. A considerable financial investment is made in personnel and other employers will take advantage of this investment if we don't conserve it. Availability of qualified personnel in this field is greater now than anytime in the past, but we must improve the salary situation and, at the same time, insist upon high standards. We must allot more time for continuing personnel training programs. We must develop and maintain comprehensive standard procedures. We must provide working space conducive to productivity. (In other words, on a par with the quality of space allotted to the computer.)

Beyond this it is necessary to establish more realistic deadlines. The user must recognize that adequate system design and programming require considerable lead time for proper implementation. In this connection, the time necessary must be taken for proper and complete documentation of the system. This point cannot be stressed too greatly since it usually becomes the weakest link. A properly designed system can fail miserably if adequate documentation is lacking.

We must educate the user to the fact that data processing is not a cure-all, but rather another tool to be used. The users must become more knowledgeable of data processing and more intimately involved than they have been in the past. In fact, this has been the user's biggest failure. In some cases, the larger users should hire their own systems analysts and programmers.

We must make use of several areas of support not now widely used in Montana. An effort must be made to see that the user is aware of the availability of generalized software. The users must be shown the savings that can be had with minor variations in what they would like to have. Generalized programs may be developed or purchased from software vendors. Presupposing the usability and adaptability, ordinarily a considerable savings can be had by purchasing a software package rather than development in house. For complex applications, particularly those which must be developed in a short time, use may be made of outside consultants. This method ordinarily costs more and may not always be desirable for a number of reasons. But this can eliminate the need for short-term staffing requirements which may be difficult or impossible to accomplish.

These methods are not solutions in themselves, but rather can supplement in-house processing.

In the past, it has been easy to say that system design and programming problems are due to the great expansion in data processing made in the past few years. Not any more! We have recognized the problems. They are presently being attacked with vigor and we will need your help!

COMPUTER PLANNING IN LOCAL GOVERNMENT

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Missoula, Montana

We in local government in Montana don't really have any problems with computer planning because we simply do not have the sophisticated computer equipment required for management planning. This simplifies the problem.

Why don't governmental units at the local level--county, city, school districts--utilize the advantages of data processing systems? There are a number of reasons. There is a general lack of knowledge on the part of the local governmental officials as to what are the advantages of such a system. They visualize computers only in extremely large organizations, so they don't even think about the possibilities. Too many of the local government units in Montana are restricted by antiquated laws, procedures, rules and regulations against the creation of such a plan. There is no clear-cut authority, for example, for a county government to establish a data processing system that cuts across the lines of responsibility of various elected officials. If a plan were established, it would sit in limbo, existing without any clear-cut authority. There is even less authority for that hypothetical county government to pay the wages that are adequate to attract qualified personnel into those operations.

There are 56 counties, 10 or 12 major cities, 758 school districts and innumerable towns, villages and special taxing agencies in this state that could utilize the advantages of sophisticated data processing systems. The possibility is precluded by cost, but cost is not the only hindrance. It is precluded even more by the lack of any historical precedent for the cooperation of local governmental units in solving their problems together. We have a tremendous duplication of effort in the various political subdivisions in an attempt to solve some of their information handling problems. In Missoula County, we have four primary taxing units: county, city, Missoula County High School System, and School District 1. These four units together have already invested better than $150,000 in mechanical data processing and data handling equipment. The operating expenses on this system are approximately 30 percent of that figure every year. If a poll were conducted on the commission members, supervisors, and elected officials, it would be evident that very little of their information is handled by that system. It was designed as a stop-gap measure. It handled the problem at the time that it was adopted, but there was no provision made for any future application or the generation of any additional information that is necessary on a relevant timely basis.

I want to appeal to those people who are here or who will be in control of the development of a master plan for computer use in the state of Montana, to not forget that there is a huge amount of money--several hundreds of millions of dollars--expended every year at the local governmental level, and there is really no effective, viable management information system utilized. I would like to see the impetus for a master plan supplied on a local governmental unit basis, but I

don't think practically that is initially possible because of the lack of cooperation between the small political subdivisions. I would hope that the planners would give due consideration to the establishment of regional data processing centers that would allow a costsharing basis and a timesharing basis of the smaller governmental units, so that each of those individual political subdivisions would participate in the operation of this regional data processing center on the basis of the amount of time that they use, or on their ability to pay. Only in this way can some of the problems and the needs of local governmental units be solved. If they are not solved in this way, there will in all probability be more duplication of effort, and a continuance of the approach where the larger tax communities will continue to spend larger and larger sums of the taxpayers' money to upgrade their own systems. Yet the taxpayers' pocketbook will have to continue to pay for this duplication of systems. If the state, the counties, the cities, and the school districts can get together and devise a plan that will alow small governmental units to have the advantages of a sophisticated data processing system at a fraction of the cost, I think that only then will we see the advent of effective management in Montana local government.

DATA PROCESSING SYSTEMS

James W. Sawyer
Data Processing Director
Montana Highway Commission

In view of the fact that computer systems are becoming more sophisticated and necessarily more complex, the greatest demands on data processing are installation management and the control of the data processing function within the organization. The data processing division in the Highway Commission is basically a service organization charged with providing computer service that will enhance the overall efficiency of the subfunctions within the Highway Commission. This is accomplished by providing rapid and accurate access to necessary information, reports and calculations when a moderate to high volume of data is involved.

In the past, data processing has been concerned mostly with development of individual programs which will satisfy certain basic needs. Now, however, since there is greater demand for more accurate information and more processing for decision-making, and as computer systems are being developed to store more readily accessible information, we find ourselves developing systems which will integrate certain basic information to enhance the overall decision-making process.

We are finding ourselves confronted with terms which for all practical purposes did not exist 10 years ago: terms like modern techniques in planning; simulation; management information systems; integrated engineering systems; data integrity; file security, which is very closely related to civil rights; and many others too numerous to mention here.

In order to avoid many false and expensive starts in the development of integrated systems for information processing, we must plan as we never have before. If I may steal a phrase, planning is imperfect work beset with uncertainties of all kinds. Yet, it is essential to keep the gap between disaster and simple variance wide enough to enable progress to be made in some orderly way. Rewards resulting from planning can have an unusual slant--for it is not what plans can make happen but rather what they can prevent from happening that makes them vitally important.

We in data processing management are well aware of the close scrutiny with which we are now faced. The decade of the 70s will see the field of data processing management mature. Gathered here, we represent major data processing users or managers in our respective agencies. Whether we like it or not, the size of our "automated" facilities are becoming major expenditure items in our parent organization's budget. We are therefore being forced to mature because we must now stand accountable as never before to demonstrate precisely the return on the tremendous investment we have made during the past few years.

Even those of you who may be pushing your chairs back because you feel you are not involved, or are only a user of data processing and what I have implied only relates to data processing management, had better believe that you are deeply tied to this "treadmill of progress." You must now define your needs and processes in ever-increasing detail because they must become integral links in the operating chain of state government and subsequently information development.

Even the users of data processing often feel left in the dark in communicating with data processing people. This is both a problem of communications and education. The problem of education can be solved with proper involvement with the problems and processes of data processing. Given enough time, it is virtually impossible for some of this not to rub off. The problem of communication is a much greater problem. The success or failure of the development and installation of any computer system depends on how well the problem was defined when the system was started. This requires exceptional communication between qualified programmers, systems analysts, management and the user agency personnel. Too often, management or user agency decisions are left to the programmers. This problem is not unique to any individual major organization.

Computer activity in most organizations does not receive the serious top management attention which one would expect in view of the magnitude of the investment and the potential benefits.

In order to solve some of the system development problems we are constantly communicating with other state and nationwide agencies to exchange ideas, computer programs and systems. This has been relatively successful in the past through such user group organizations and share organizations as the Highway Engineering Exchange Program. For the most part, however, pure application programs should be solved or competently reviewed by personnel closest to the problem; that is, personnel at the functional level.

It should also be noted that a computer is of little value without competent individuals to manage, design systems, program and operate it. We in data processing are vitally interested in closing the gap between the various computer users, potential users, and the computer itself. Advancements in modern technology are providing us with facilities to partially achieve this goal. This can be accomplished through direct communication with the computer via teleprocessing, more complex systems simplified to the user's standpoint for data management, computations and report generating. However, for the most part, the processing of voluminous data will still remain with direct communication between user agency and personnel in data processing.

Personnel in data processing normally consist of systems analysts, programmers and people involved with computer operation. In many of these cases special aptitudes, special training and special characteristics are generally required for certain positions unique to computer work.

The success or failure of any installation is not dependent on the sophistication and complexity of the hardware resources or with the software package program. It is entirely dependent on the quality and qualifications of its personnel.

PANEL DISCUSSION

Moderator: Patricia Douglas
Assistant Professor and Research Associate
University of Montana
Missoula, Montana

Moderator: Each panel member noted in his own way that whether user or processor, in terms of involvement, administrators will each face the issue of establishment of priorities, and that these priorities become important particularly in Montana when put into the context of limited human and monetary resources. The idealistic need, unless our planning efforts are really coordinated, could well exceed either the state or the various local budgets, and yet there are other priorities of universities, of local governmental units, and of state government. These efforts in the future might not be coordinated unless we somehow strengthen the communication ties among users, processors, and various governmental units. The requirements to solve this issue of priorities are many, and they include planning, changes in laws, changes in attitudes, changes in precedent, changes in well-established and well-ingrained priorities, and changes in organizational structure. There are many others, but these are sufficient because we have so little time to tackle each of them and to solve them all.

Question: In about two-thirds of the states the university system is separate from the remainder of the state government; in the remaining one-third it is an integral part of state government. In Montana, it's both. In order to acquire equipment for computing, we must abide by the legislation and statutes that require the state controller to approve any acquisitions. The accounting and budgeting phase of it, however, is entirely up to the university until we're able to come up with a concrete procurement plan. Within the university, there are those who believe that the university should remain isolated from state government, those who provide counsel to the government that has no political value who also are not bothered by political bias in the computer center. On the other hand, thereare those who believe that this is an ivory tower approach and that the university should become more a part of the community, the state, and the government and become involved. I personally have no feeling either way on this; I do see advantages pro and con on both sides. I feel that if we are to become an integral part of the state we could give the controller a little bit more power; right now, the statutes really give him power only on a procurement basis. Right now we can be run by the vendor. If we acquire a machine they dictate the terms of acceptance, and the terms of maintenance. The state should be on the level of where the vendor submitting a bid on a procurement has to sign papers that require him to have an acceptance period similar to what the U.S. government requires, that entitles the buyer to a certain amount of maintenance--I think we'd be better off.

Discussion: I would say in answer to the issue of establishing contracts and rules under which the vendors should bid, that this is a good idea. This can be maintained throughout the state, but I'm not sure that the Controller should have the sole control in this issue. The university is somewhat of a community by itself. If things do change, however, we do have a responsibility to the whole state. My view is prejudiced, however, because the University of Montana's capabilities are so limited. I wish we

had a better computer capability in order to participate effectively in the state. It might make a difference if that were the situation. I feel that if your're going to talk about the issue of there being a centralized committee or person for data acquisition, you're going to have to talk about a centralized buyer for automobile acquisition, for laboratory acquisition, and many other necessary pieces of equipment.

Question: I've been quite astounded at the variety and amount of data processing equipment in the state of Montana, and I feel that our computer systems have grown like Topsy, all over the place. Has anybody made an inventory of the computer capabilities that we have in the various universities in the state?

Discussion: The Controller has an inventory of the equipment, and by the fact that we have an inventory of the equipment itself, we can determine the equipment's capabilities. However, determining the capabilities of the personnel in the state is a difficult matter. We don't have a software inventory, or an inventory of programs. No one truly knows whether the hardware is being used effectively and efficiently. We need a summary of both the hardware and software in Montana to compile a report for future planning.

Question: If this is the case, it seems that one of the first steps in state planning is to compile such a report. Do you think the acquisition of computers ought to be stopped until such a study is made?

Discussion: Yes, we need a cost-benefit analysis. Possibly it's a little harsh to say that obtaining computers within the various state agencies is a status symbol. This is certainly not true in most cases, particularly on a cost-benefit analysis standpoint.

Question: One of the things this discussion has been missing is the necessity for broad legislative guidelines, and wouldn't it help to have these guidelines?

Discussion: There are no guidelines. As far as I can see, there is only one starting point to solve this planning problem, and that is with the Controller and the Advisory Committee. There is an executive order requesting that all data processing be checked out with the Controller.

Question: Is there an inventory of <u>all</u> data processing equipment in Montana?

Discussion: No, just for the equipment in state government. Perhaps some of the vendors have an inventory of other equipment.

Question: There seems to be a shortage of jobs for computer personnel in Montana, yet the state is understaffed, and there is not as much emphasis on training as I thought there might be. Why?

Discussion: Nationwide, the schools that are training data processing people have basically done a very poor job. The vo-tech schools are flooding the market with people who are qualified in only one area, and they are all qualified in the <u>same</u> particular area. There are too many prospective employees on a training level which is not high enough. Some private schools were organized just to make money in the data processing field, and they are going out of business now. We should support the vo-tech schools, however, and make sure that they try to remedy the situation. The situation is especially bad in Montana; there just are not that many jobs available. The vo-tech should

do a better job of giving these people broad backgrounds in data processing. The Montana Data Processing Association is meeting in Whitefish to formulate some suggestions to the various technical schools.

There is one other thing--on the labor market, which should be watched quite carefully in so far as data processing education is concerned, nationally, there are a lot of data processing people being dumped on the market because of the cut-backs in aerospace. This is one area in which we could possibly enjoy an influx of highly competent people already trained and qualified.

NATIONAL TRENDS IN DATA PROCESSING

Herb Swartz
Assistant Controller of Information Systems
Atomic Energy Commission

Electronic data processing is the most rapidly growing major activity in the American economy. It soon will exceed the dimensions of the automobile and other older, huge industries. A large number of trends are emerging in this growth. Today, I want to focus on five selected classes of national trends in computing and data processing. An appreciation of these trends might help you come to grips with many of your own local problems. These five areas are: 1) equipment technology; 2) programming; 3) applications of data processing; 4) internal management; and 5) the potential social problems which the legislature has to weigh in its considerations.

Equipment trends first. Automatic computing speeds are continuing to increase at extraordinary rates. Nothing in the history of our society has moved this fast in this short a time. The Univac I, which introduced the commercial age of computing, was in fact turned on for the first time in Philadelphia twenty years ago. That machine's speed was in milliseconds--thousandths of a second--per operation, and that was pretty fast compared to people! That is one of the important reasons that the Univac I got off the ground so well. Then we talked about millionths of a second, which we call microseconds. And finally today we're talking about billionths of a second, which we call nanoseconds. In short, there's been a million to one increase in computing speeds in two decades. And that first machine, which was a million times slower than today's machines, was itself thousands of times faster than the human being. So the gain is really extraordinary in these two decades.

My second general point about equipment is that it's becoming increasingly communications-oriented. Increasingly, computers look like switchboards. The telephone company's switchboards can handle many calls simultaneously, and they don't misroute many of them. Computers are going to be like that. Instead of doing one thing at a time, like the old Univac I, they will be able to handle many transactions at once. If you were doing a payroll, you had to finish the payroll, because if you stopped at any one place, you had to restart at the beginning. Nowadays, computers are like switchboards, which accept calls from all sorts of places, and which handle at one time, as it were, the many demands being made upon them. And I think it would help if you thought about the new machines as switchboards, except instead of switching telephone calls, they are switching computer capability.

My third general point about the technology has to do with data acquisition. How do we prepare the information for the machine for it to process? Well, for a long time we relied upon punched cards. The problem with punched cards was that it was a separate, distinct, additional step that had to be performed. That is, human beings took human documents (transactions, forms), and keypunched them; i.e., they copied the information onto cards.

About 15 years ago, something came along called source data automation. By the middle fifties, a clerk operating a bookkeeping machine, a typewriter,

or an adding machine, could simultaneously punch cards or punch paper tape. So when the Univac was only five years old, breakthroughs began to occur in how data were prepared for the machine. By the late fifties, magnetic ink character recognition came along, so that a machine could directly read a human document. This was an obvious improvement over key-punch and source data automation, because the document itself became an input to the machine.

More recently, optical character recognition was developed. The first optical character recognition machine of the late 1950s could recognize only one type font. We now have machines that will read twenty type fonts; and in a decade, we expect to have machines that will read "any old type print." How soon--if ever--they'll read handwritten print is a question. One manufacturer has a machine which will read certain very carefully blocked-out handprinted characters. How soon it will be able to handle a whole alphabet and numbers is uncertain. Whether it will ever be able to handle handwriting on just any old document, I personally doubt. The intellectual demands for that are beyond our capability.

Finally, the most recent innovations with respect to feeding data into the machine, are direct entry data devices, where the human being performing the operation "transcribes" directly to the machine--as he performs some operation, the data enter the machine. For instance, at Northwest Airlines, the agent--while talking to the customer, making out tickets, etc.--with the typewriter, is "talking" to the computer at Minneapolis.

There have been other kinds of fancy inputs, such as light pens, so that a designer can sketch a drawing on the face of a cathode ray tube and the machine interprets it. There is something called the Rand Tablet, developed by the Rand Corporation, where a man can use an electrical pen to print on the face of an electrostatic device which "talks" to the machine. There is also a device now that a human being can touch in various kinds of ways to tell a machine what to do. Some experimental machines have voice input--the operator can say, "Stop," "Go." I think these are kind of fancy, and we probably won't see much in use for fifteen or twenty years.

Finally, there's the telephone, used as an input device through touch-tone terminals. Commercial banks, for example, are beginning to use touch-tone devices whereby the teller, as he processes a transaction, "talks" to the computer by telephone.

The point is, there is a proliferation of input devices, and this enriches but complicates the equipment selection decision.

That's one side; that's how the data gets into the machine. There's been a vast proliferation and a vast transformation, and the point is that increasingly they're becoming more and more human-oriented. Punch cards are very remote from the human being. Pushing the buttons on the dial of a touch-tone telephone is very human-oriented. This is something we know how to do without being taught. This is the important point--increasingly these devices are becoming humanly easy to use.

Now on the other side is data presentation, or getting the results out to the human being. The first machine had line printing. This was followed in the late fifties and early sixties by graphical displays of all kinds.

We call them "cathode ray tube displays"--TV-like tubes where the machine projects the results of the processing on the face of the tube in printed or in graphical form. And increasingly, these cathode ray tube devices will probably become the most commonly used input-output devices, the most common way of presenting data to, and collecting results from the machine.

Let me just mention two other kinds of data presentation. Microfilm is an exciting possibility. Certain things are required to have hard copy back-up. We in the A.E.C. are eliminating paper by using the computer to produce microfilm instead of paper. The computer itself produces the microfilm--we don't print the paper with the computer and then microfilm it; the computer makes the microfilm as direct output.

Finally, the most human of all output devices is the telephone. It's called "voice answerback." In about 1967, the first commercial banks began to use it. The teller picks up the telephone when you go to him to cash a $500 check, and he feeds in your account number by touch-tone dialing. The computer says, in voice recorded output, "account number so-and-so of such-and-such a person has a balance of this much." The computer literally talks back. It talks back because all the possible things that the computer will say are recorded, and all the machine does is select the appropriate pre-recorded words. Since this is prerecorded by human voice, you can have any voice you want--a Southern accent, a Montana accent, even a French accent if that would please you.

These data acquisition and presentation devices are now being shaped into gigantic networks, and the network idea is becoming increasingly structured. That is, we have human beings working directly with machines through these data acquisition and data presentation devices, and we have machines working with machines. In the future, increasingly, we will have human beings working at terminals "talking" to small computers. If these small computers cannot handle the problem well, they will pass the problem on to a larger computer within the network of which they are a part.

All this has been accompanied by an incredible decline in cost. The capability of these machines has been increasing in relation to cost at an extraordinary rate; yet, the total cost has risen. The total cost has risen because the uses of the machine, the number and intensity of applications that are applied, are increasing faster than the per-unit cost of computation is declining. In other words, total costs, for instance in a state like Montana, have risen because the state's appetites are growing faster than unit costs are declining.

Now, as to programming. Programming is essentially the way in which the human being directs the machine to get results out of it. The Univac I was directed by what we call "machine language." If you had walked into a Univac computing center in 1952 and said, "Hey, Mr. Programmer, show me a program," he would have shown you a sheet of paper which looked like heiroglyphics. He'd have all kinds of strange marks on it as well as the familiar letters of the alphabet and familiar numbers, but in patterns that would look to you like some mysterious code or peculiar cypher. This was the way people directed machines--in the "language" of the machines.

Programming became a very, very tight bottleneck because of the huge increase in computer applications. By 1955, the problem in the United States in using computer equipment in aerospace, in military applications,

in the Federal Government, and in private business was not the availability of the computers but the availability of programmers. In order to surmount this problem the computer was turned on itself; that is, people learned how to teach the computer how to help the programmer write his program.

Nowadays, computer programmers spend one-eighth to one-tenth the time they used to spend because the computer is now part of the programming process. There are what we call algebraic languages--FORTRAN (formula translation) is one such language. The programmer writes a mathematical formula down on paper, feeds that into the machine, the machine translates it into a program, and executes it. A programmer can write down x = y + z eight to ten times faster than he can write down the gibberish of the earlier machines. Another kind of language is called COBOL, which means "common business-oriented language." Nowadays, most everybody uses COBOL for business data processing, provided they have a modern machine. If you're still stuck with an ancient machine, and you cannot use COBOL, then you cannot be as efficient in your business data processing and programming as you can with more modern machines.

The point here is that like the hardware, the software (which is what programming is called) is also becoming increasingly humanly oriented and easier for people to use. "Interactive programming" is a recent development; the programmer works with the machine a piece at a time. He says to the machine, "Read x, y and z." Then he says, "k = x + y + z + r." The machine will stop and print out, "But you never told me to read r." In short, the machine interacts with the programmer and every time he makes a discernible mistake--except of course in basic logic, which the machine cannot know about--any time he makes a linguistic mistake, a "syntactical" error, the machine stops him dead. This is another way in which the machine is becoming increasingly humanly easy to use.

Some people belive that in the next few decades we'll have problem-solving machines. That is, instead of telling the machine what procedures to follow, or what steps to follow in solving a problem, we will be able to tell the machine what our problem is, and it will sort through a repertoire of problem-solving programs and select the one appropriate to the particular problem. Whether or not problem-solving languages will ever work is a question in my mind. But I must advise you that there are people thinking this way, and my reason for telling you about this dream is simply to open up your minds to some of the very distant possible opportunities.

Now let's say something about applications. The first applications of the first computer were engineering and scientific calculations. The very first machine could only do complex number arithmetic. For those of you who remember your algebra, in order to multiply two complex numbers, you have to go through more than ten separate operations. In order to divide two complex numbers, you have to do even more separate operations. And all the first computers could do were these two things: if you told it to multiply or divide two complex numbers, it would take all the necessary steps automatically without any human intervention. That's what really made it a computer--the fact that it did more than one thing automatically in sequence. A desk calculator would multiply for you--but only one thing at a time. This machine could do thirteen or fourteen things with a single push of the button.

The second class of computers was more general. They could solve any mathematical problem of simultaneous linear equations. Put into plain English, these early machines were built for handling ballistics--firing tables for the United States Army and the United States Navy. They helped men decide how to point a gun to drop a shell exactly where it was wanted, particularly when it was fired at an unseen target over the horizon at sea or over a hill on land. There are tables telling how to do these things, and these tables are the resolution of very large families of simultaneous linear equations. The early machines could do these equations, but that's the only kind of math they could do.

By 1944 or 1945, Harvard University had a machine called the Mark I, built by IBM, which was a great breakthrough--it was general purpose. It could solve any problem that could be described in arithmetic. Not just complex numbers--not just simultaneous linear equations: this was any kind of arithmetic, including the approximations for partial differential equations and other very sophisticated problems.

The first general applications were engineering and scientific calculations, and of course, such applications have persisted heavily to this day. It probably is still the largest use of pure computing resources. Today the Atomic Energy Commission has eight machines, all locked into a system called "Octopus," in Livermore, California. We have eight of the world's gigantic machines and they run 24 hours a day on scientific problems. What we like to do is to simulate the firing of a weapon instead of actually firing the weapon to find out how well it might work, and we do other kinds of engineering and scientific calculations. We are probably the largest user of pure computation support in the effort to do things better and safer, and at lower cost.

The second class of computer work outside engineering and scientific calculations is bulk transactions processing. The first commercial company to have an electronic computer was the Metropolitan Life Insurance Company. The effort was to make huge repetitive, low skill, bulk transactions processing faster, and more importantly, to reduce the costs. Univac I could do bulk transactions processing at less cost than could people, so business and government made immediate use of the machine. In fact, the first Univac was delivered to the Bureau of the Census to tabulate the 1950 Census of Population, which is a transactions processing kind of thing. In any event, the effect was, once engineering and scientific work had been proven out, the very same machine was used for business data processing. The only difference was, the arithmetic for business data processing was very simple and data acquisition and presentation were more serious problems.

The third level of application, other than engineering and scientific calculations and bulk transactions, are "information driven" systems. The objective is to improve the performance of general executive and line management in government and business enterprises. Better informed management means better productivity. So far, the machines have mainly been helping middle line management, but we're learning increasingly--we're slowly climbing up the management levels to help more and more senior executives. I personally do not have the image of the president of every large corporation sitting down to his desk computer every day; however, some of them will do it in the next decade, and a few, like Terence Hanold, President of Pillsbury Corporation, are doing it already. Mr. Hanold designs his own corporate models and runs them on his own terminal

in his own office. In any event, the third level is not to do calculations, not to save money, but to spend money in order to get better information for better management for the sake of improved total organizational payoff. I'd like to think that it's those things which are the most important drivers for the use of computers in the State of Montana.

The fourth level of application is to combine engineering and scientific calculations, bulk transaction data processing and information driven systems in the advanced, sophisticated analytic support of decision-making and policy-making in government and private affairs. We may be able to do this in two ways.

In the first place, we apply the long-standing traditional techniques in statistical methods to large bodies of data. We do things every day, every hour, which ten or fifteen years ago could only be done on a very selective basis. When these machines combine the ability of calculating with large-scale bodies of transactions we can get swamped in using methods of the past to interpret information. We need to use the machines for statistical analysis to improve our understanding of the structure of a given event. One of the most important uses in the United States, for example, is in discovering the determinants of consumer spending. When do people increase their spending and when do they decrease it?

The second marriage of calculating data and information is what Hugh Galusha mentioned this morning: model simulation. The first modeling and the first simulation were done in the airplane industry. In 1954 and 1955, some bright people working for Lockheed, North American, and other places said, "Look, we ought to stop making miniature models of potential new airplanes and putting them in wind tunnels and spending millions of dollars testing these airplanes, 99 percent of which we're never going to build. What we ought to do is write computer programs to describe how our atmosphere behaves, what are the laws of aerodynamics, and in short, teach the computer to make believe it's flying an airplane to produce for us the same results that we get out of a wind tunnel."

Nowadays, this is an everyday affair. Telling the computer how to represent the earth's atmosphere, describing to the computer the laws of aerodynamics, how an airplane works, what happens to the wings, engine, fuselage, etc.--putting all that together is called "building a model of an airplane in flight." When we fly that make-believe airplane in the make-believe atmosphere, the experience of real life is simulated. The objective is to answer the question "what if--what if we made the wings shorter, the tail higher, dropped the engine, increased the horsepower, increased the load, the fuel capacity, etc., etc.?"

Nowadays, the plane is built and flown in the wind tunnel only after the design work with the computer is finished and they really just want to check it out. The reason they want to check it out is because maybe they were a little inaccurate about how they described the universe to the computer, and so they finally need to test a handmade model. Thus, if the computer model works, they build the final airplane.

We can now design airplanes at lower costs and increase the range of options available to the designer. If a designer had to change everything about an airplane with which he was experimenting, he could fool around with the wings, and that would take him six months; he could fool around

with the tail, and that would take him another six months; soon the airplane would be obsolete. Working on a computer, he can simulate these and thousands of other changes in a matter of a few weeks or months.

The fifth general field of application, and we're not too sure how well we're going to do with it, is a very important one. It has to do with the library of the future. There are more technical journals being published today than there were people in the world not so very long ago. I'm sure I'm giving you a gross exaggeration, but someone told me there are now 50,000 journals in the field of biology. How can people get through all this stuff? Well, it looks like we need machines to do it. People are beginning to use computers for what we call "technical information storage and retrieval," and it looks like we're getting there; some breakthroughs have been made. It is entirely possible that in ten or fifteen years, when someone wants to look at a document, the document won't even be there. It will be presented to him by a computer on the face of a cathode ray tube or some other device perhaps not yet invented and maybe not even yet foreseen.

The sixth data processing application is process control. In process control, the computer becomes an integral component of the production process. The first place to use this was petroleum refineries. There, the production level and composition is constantly changing from more or less diesel oil, more or less high or low grade heating oil, more or less gasoline with high octane, etc. These changes are made by turning valves, and people decide which valves to turn depending upon cost-price relationships. Every day, every modern refinery now runs something called a linear program. That is, they feed into the computer all the cost-price and demand variables, and the machine outputs the optimum production mix, which in turn is given to a process control computer, which controls the valves, and monitors the production process. If something happens to the octane rating of the gasoline, as it measures it, it changes valves where necessary to get the production process back where it is supposed to be.

In the world of atomic energy, we have one machine that sits on a reactor and which monitors 3,500 variables simultaneously, all of the time. These 3,500 variables have to do with temperature, pressure, and other activities that are occurring inside the reactor. Now then, the machine is busy all day long making small changes on various devices to keep the machine operating within 3,500 limits earlier determined by people. The machine is not only checking the pressure, or the temperature, but also investigating what has been the recent change in temperature; if there's a gradient in temperature that's too fast, the machine takes the same kind of action it would take if the temperature had reached an extreme level. So the machine is watching change as well as level, and the machine has the capability, if it sees the system is getting out of hand, to "scramble" the reactor. That is, it can drop all the rods in place and stop the reactor, so it has precious safety connotations as well as better production connotations.

The seventh application is what we call on-line computing. In a way, this gets back to technology; in a way, it's a little different. I just want to mention the fact that increasingly applications involve people "talking" to machines. Bank systems, savings and loan systems, airline reservation systems are beginnings. Increasingly, we will see this proliferate throughout administrative and business levels.

The eighth kind of application is the one that's particularly perplexing--how best to use the computer in the university. The computer is used in the university across the entire range of applications I just described. A summary of computer uses in the university might go as follows: the machine watches the university budget; the machine is used by the students as a learning and research tool; the machine is used by the faculty as a full-blown research tool; the machine is increasingly being used as a teaching aid; and finally, the machine is being used as a subject of instruction itself. This is a pretty wide range of activity. As Bob Bannaugh said this morning, university computers are something very special and maybe they should be given very special consideration.

The university is being transformed by the computer. I want to quote the Chancellor of the University of Texas, who put it this way: "There was a time when we judged a university by the quality of its students, its faculty, and its library. Increasingly, there's a fourth variable--we also now judge a university by the quality of its computer." That the university of the future shall be known by the capability of its computer plant is quite a revolution.

The fourth broad class of trends I wish to examine is the internal management of the computer activity itself. We're so busy helping other managers manage their affairs that we in the computer field have done a pretty poor job of managing our own. There are big changes occurring--there's a lot of new focus on management of the data processing activity.

Why is that? In the first place, even though computing per unit is getting cheaper, total computer costs are rising. Secondly, people are becoming increasingly aware of the wide range of potentials that I've given you a glimmer of, and they want them, so it's becoming increasingly incumbent upon data processing managers to get results out. In short, they've got to step up their management productivity too. The third source of movement in management improvement inside the computer area is the rise in the management level of appreciation.

One of the things you want to consider in debating how you're going to structure all this--don't just worry about how many machines and where they're going to be--is management of your computers. There's no sense in your reinventing our wheel. PAY NO LESS ATTENTION TO MANAGEMENT OF THE COMPUTER FACILITY THAN TO THE EQUIPMENT, ITS PROGRAMMING, AND THE APPLICATIONS PLACED UPON IT.

Now let's turn to the social impact, the social sensitivity. First of all, I want to get rid of a bugaboo: that is, that computer technology will be like the steam loom that replaced hand looms in England in the 17th century. On balance, people are <u>not</u> going to be thrown out of work. There are <u>more</u> jobs being created in the computer industry every year than there are people being displaced by computers. Why? Because the hungriness for applications, the desire to do all the things we've been talking about, is putting a tremendous demand on designers, on manufacturers of equipment, programmers, and systems analysts. In any event, we don't have to worry about that problem. Some new industries really have to worry, because they put people out of work; they replace human labor and cause unhappiness. Computers won't do that; we've known for twenty years that they will generate more jobs than replace.

Now the second kind of bugaboo is more real; it is not a bugaboo; most modern industrial products do create one kind of pollution or another. The computer will create some pollution, too, of its own kind. Pollution is the side effects of otherwise highly meritorious advances in technology. Pollution is a by-product. I'm going through this point just to make sure that we do not only think of computers as pollutants; technology pollutes and much of the pollution is hidden. Some of the pollution that we think we are now excited about is smaller than the pollution that we will soon be excited about. It's been estimated that the amount of refuse or scrap being generated by the American society ten or twenty years from now would cover an area the size of Rhode Island ten feet high. We will soon be having a scrap disposal problem in this country of enormous magnitude.

We are polluting through the computer in the form of generating wholly new and deeply pervasive dossiers that represent violent threats to the privacy of individual citizens. Computer files can be so large, so cheap, so easily updated and extended, that they can amass overwhelming amounts of information about any one of us. We must face up to this form of computer pollution--and we are clearly beginning to. There are many people worrying about it, like Congressman Moorehead from Pittsburgh who's been cooking up Congressional bills to control computer storage. Some state governments are also worried about computer pollution. The point is that there are various pollutions which you'll want to consider in your planning and in your study of how to use computers in Montana government.

The second pollution is recentralization of organization. Information is a source of power. If enough information is brought to a place where it can be handled efficiently, it eliminates the need for decentralized organization. The major role of decentralized organization is to handle information. The boss can't know it all, he can't make all the decisions; the more complex his organization is, the larger it is, the more he has to proliferate decision-making and the information that goes with it.

Computers threaten decentralization in American life. I believe in decentralization and I do see that the computer is a possible threat. Two things may, in the end, prevent recentralization from happening. In the first place, decentralization with computers may in fact turn out to be a bomb, a dud. It may be that the systems will be so grotesquely over-complicated that human beings won't be able to program them. We may not be able to build--and I hope we never learn how to build--highly monolithic systems for business and administrative organizations.

The second thing is the managers. People--academicians--say, "Wait a minute, you're not going to use these machines in every possible way, any more than you use atomic bombs, or other inventions in every possible way." Organizations may need to do this sort of thing with computers in order to protect their vital decentralization. One thing is wrong, and that is to say, "We'll protect decentralization by not having computers around." That's throwing the baby out with the bath water.

The third pollution of computers is not something you have to worry about too much in Montana in 1970, but modern large-scale production industry in places like Detroit, Toledo, New York, and Los Angeles has the problem. That is, process control computers, by doing better what people used to do, further dehumanize the production process; they add another level of automaticity. There is less for human beings to do in the

production process, and therefore organizations and people are becoming virtually irresponsible. We all know nothing works, and if you go to have it fixed, nobody can fix it. And if it is fixed, the repairman breaks something else while he's fixing it. That's my law of automobile mechanics. My only solution is to take my beating along with the rest of you. I say that this has happened because of the dehumanization of the production process. The people involved don't care--it's a national and worldwide phenomenon.

Dehumanizing our production processes began with the age of automatic machinery, and the computer is such a super automator that it's going to add considerably to the problem. One thing may save us, and that is the fact that so many jobs will be created in the computer industry which are highly human in nature--people program and people wire these machines and people shove the tapes through them--that maybe we'll find a new humanization in the large numbers of people who will be doing exciting and interesting things in the computer world which they didn't have the opportunity to do before computers. Maybe there will be a trade-off. But even if there is a trade-off, it isn't a total trade-off. The fact of the matter is that on the negative side, there will be a further dehumanization of the production process and therefore an increasing complexity of management in getting things built and done.

Computers, terminals, applications--these are clearly part of a gigantic feedback mechanism. That is, the more machines we make, the cheaper they get to make. The cheaper they are to make, the more people use them. The more people use them the more applications there are. The more applications there are, the more potential customers there are. The more potential customers there are, the more the manufacturers make. So there is a loop, a circle, with the feedback for each event increasing the demand someplace else in the circle. And we go round and round. What has happened is that costs have been dramatically cut inside the computer field, because we've had volumn production; more machines are being built per year. We use computers to help build computers--in short, we're improving the computer manufacturing technology. Both of these advancements are reducing costs. Feedback depends on decreasing costs and we've every reason to expect them to continue to decrease and to expect a richening of applications.

Consider the history and sweep of computers and data processing. A computer was once just a calculating machine for complex numbers. Then it became, in twenty years of development, an information-handling machine. The machines are really not called computers any more; increasingly across the country, college "computer sciences" departments are being called "information science" departments. The machines are much more than arithmetic calculators; they are information handlers, very generally in the sense of accepting information, processing in all kinds of ways, storing it, making it easy for human beings to use it and to get to it. This is a profound revolution in information.

Two things distinguish the human being from all other creatures: religion and information. When we're talking about intelligence and all the rest, we're talking about information. Human beings are information processors. They observe, store, call up, and act upon the basis of what they've been taught, or what they've learned. John McCarthy of Stanford says that we once considered the universe to consist of matter and energy. All of nature could be said to consist somehow of matter and energy or their

transforms. And McCarthy says, now we know that in our universe there are three all-pervading elements: matter, energy, and information.

Now I want to ask three questions: Can a machine think? Is information so important that a machine can think for us? My answer is no, a machine cannot think, and machines will never think in the sense in which we humans can think. But machines have certainly invaded the thinking process. Before we had check sorters and computers in banks, checks could only be sorted by human beings. People had to look at a number and decide which box to drop that particular check into. You cannot teach monkeys and gorillas how to sort checks. Only a thinking human being once could sort checks; now machines do this so much better than people. What we do have to recognize is that machines do not think, but they do perform processes that otherwise only thinking human beings can perform. The machine is invading the thinking spectrum.

Second question: Can a machine decide? The answer is, "Well, it depends upon what you want to decide." Do you want to decide whether we should go to war or not? No. Never. Do you want to decide whether a traffic offender has been convicted two or three times before? Whether his automobile license is outdated? Whether or not he's wanted in California? Whether or not this or whether or not that? The machine can decide that. To answer the question of whether a machine can decide: yes, at a very low level. And that is one of the machine's crucial roles in administrative work: to do the lower levels of deciding and leave the important decisions up to people.

The third question is: Can a machine plan? The answer is no, it never will. Moreover, although machines have invaded the thinking process, and although machines can decide on a certain low structured level, machines will never be able to plan. But, they will help planners do the planning. Better information, newer models, better analyses, better statistics, the capability of asking "what if" we raise the taxes, what if we change this benefit in this way, what if we build a highway there instead of here? All kinds of questions which state governments are confronted with. Machines cannot answer these questions, but they are very powerful analytic tools helping the man who must solve the problems.

I wish the State of Montana the best of success in its attempt to handle some truly difficult decision problems. Computing is rewarding, but it is costly; it must be harnessed in a balanced, hard-headed, cost-payoff, no-nonsense way.

FUTURE DATA PROCESSING TRENDS IN MONTANA

Doyle Saxby
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What is the future of data processing in Montana? First, computers in Montana state government will be better utilized by a great expansion of computer technology through timesharing and teleprocessing techniques. Secondly, computer centers will be better managed by increased utilization of the computer through introduction of new applications.

How does this growth of computer technology affect you as legislators, businessmen, agency heads, officials of local government and auditors? Just a few short years ago very few dollars were spent on computer technology in Montana. However, the use of computers is growing, and it's growing at a very rapid rate. This expansion is expensive; during the current biennium, Montana state government anticipates expending in the neighborhood of $4,950,000. (Interestingly, the University system will be spending about 34 percent of this, or $1,700,000.) At this time, the projected expenditure for data processing, including operators, hardware, and software--the whole operation--for the next biennium is in excess of $6,700,000. In other words, there has been a tremendous increase in the cost of data processing, and these figures do not include the cost of depreciation on wholly-owned equipment.

The growth of computer technology has another implication: each day, more pressures are brought upon managers and agency administrators to increase their computer capability. In fact, the computer is a status symbol. However, we must avoid the proliferation of decentralized computer centers; rather we must increase the effective utilization of our present capabilities. Modern, third-generation computers produce major technological advancements, which permit greater centralization by use of teleprocessing equipment and result in lower per-unit costs. Also included in these advancements are timesharing, or processing which permits numerous users access to the computer without noticeable delay; real-time processing, providing results or feedback almost instantaneously; and mass storage devices permitting the creation of comprehensive data files.

Compute r Management

We will be improving the management of our computer centers. A recent study by the Diebold Group, Incorporated, found that top management is either doing a poor job of planning or is not guiding data processing growth at all. The study further determined that corporations generally produce a great deal of useless paper as a result of computerizing their accounting and financial data. There is no reason to believe that we in government are any different.

The decade of the sixties saw an explosion in computer development and utilization; however, with a slowdown in the national economy, there has been a shaking out of the less efficient computer operations. Management has become more cost-conscious, and demands more for each dollar expended. More pressure will be put on data processing managers to

eliminate unnecessary facilities, to consolidate data processing centers, decrease rental rates and cut day-to-day operating expenses.

For far too long, in my opinion, computer technicians have been telling top management what it should be getting from the computer, rather than top management telling the technicians what it needs. Nationally, far too many data processing projects are originated by the data processing organizations, rather than by the users. There often is no analytical support for specific proposals and no cost estimate or projections of anticipated benefits. These proposals should be in a form that higher management is used to looking at. Data processing projects should be subjected to the same processes given to other capital investments of the organization. Top management does not necessarily need more reports, but rather it needs more meaningful reports.

Centralization

I foresee increasing centralization of computer capabilities in Montana. Also, in view of recent nationwide trends and past legislative action, the Department of Administration favors the centralization of data processing capabilities in central government. Centralization will require a large central processor, with multiple programming and timesharing capabilities, which can make large files of information available to many users at many locations through the use of communication lines. A large processor enables management to recruit and retain more skilled personnel and thus maintain a higher level of operating efficiency for both manpower and computers. A large central computer center permits better control and standardization of equipment, program languages, program documentation, and systems design.

Teleprocessing

The use of teleprocessing will increase in Montana. Teleprocessing gives the user the benefits of a computer even though he does not have one in his own shop. A computer terminal in the user's office enables him to send or receive information to and from a central computer as though the computer were in his own office. The advantages of teleprocessing from the user's point of view are that the user has control over his file, he determines where and when the information is processed, and distances from the computer have no bearing on his job. This is very important in a big state like Montana where distances are great. Information, once transmitted to the computer, can be stored and thus becomes part of the library of quickly retrievable information and data available for later processing.

A recent Federal Communications study says that approximately 50 percent of the computers are on-line, and that about 90 percent of the computers will be operating on-line by 1975. This means that the cost of using computer networks will likely become a significant factor in the design of statewide computer systems. Because the advent of teleprocessing is so recent, it is impossible to determine the precise impact future development will have on the established national communication network. However, the cost and availability of computer networks will become a significant factor for further consideration. At the present time, telecommunications management and data processing management are not combined at either the state or federal level. The Federal Communication Commission's report contains the following remarks:

> Telecommunications systems should be designed and developed as part of the larger data processing system...Telecommunications planning staffs should be an integral part of the total systems planning staff...The operation of telecommunications systems should be under the same management responsible for the operation of the computer system.

The Commission's report concludes as follows:

> The convergence of computer and telecommunications technologies is producing a qualitatively different national resource--teleprocessing. The fragmented Federal policy, planning and management structure wherein one element addresses ADP (automatic data processing) management and a separate element addresses telecommunications management is no longer adequate.

The Department of Administration has recognized the problem of relating data processing and telecommunications. We expect to propose legislation to correct the problem at the 1971 legislative session.

Timesharing

A great increase in computer timesharing throughout this state is likely. Timesharing greatly increases the computer utilization because many users and many operations can be carried on simultaneously. Through timesharing the power of the computer becomes conveniently accessible to administrators, scientists, engineers, educators, decision makers and problem solvers in every type of industry, government agency, and profession. Most of the original users of timesharing were scientists, engineers, mathematicians and statisticians. Lately, however, more and more administrators in all professions have become the users of the computer by use of timesharing terminals. Perhaps the most important use of timesharing in the near future will be the development of data files for management information systems. A timesharing system is ideally suited for this task. Information can be entered from any number of terminals into a central computer. It can then be, by remote terminal, processed or stored at a central location.

Auditing

Audits of data processing operations are becoming increasingly important. Harold Weiss of the Automatic Training Center in New York has said, "Very little true computerbased fraud has yet surfaced. The true computer fraud is deception about the benefits and cost of new hardware, software and systems projects; hidden costs on personnel, documentation, program maintenance and the like, poor programming and operation, etc." The Diebold study also found that a genuine audit and evaluation of production versus nonproductive time is both necessary and likely to be a standard operating procedure in the larger firms. To the consultants making the study, this is a significant fact. It shows that data processing is maturing. Government planners should take a lesson from this and plan for regular in-depth analysis of computer operations.

Computer Applications

There are many new and exciting applications of the computer which we may be able to take advantage of in Montana. Computer applications in the area of legislation include the statute retrieval system that is being installed next month. This involves putting all of Montana's statutes on magnetic tape in computer readable form. Users will be able to interrogate the computer and find all the laws pertaining to any given subject. Such capability will be of great value when preparing legislation or analyzing any given bill. Along with the statute information retrieval system the computer may ultimately be used to help write legislation.

Another computer application now being used in some states is a bill status reporting system. This enables a person to monitor the progress and status of any bill as it goes through the legislative process by interrogating the computer from a remote terminal.

Promising computer applications in the area of financial management include control and analysis of expenditures by appropriation and program, budget analysis and budget preparation, revenue and expenditure forecasting by adding various stipulated factors (this would be of great value when you want to determine the effect of any bill) personnel position control, sick leave and vacation statistics, purchase order writing, purchase statistics, and cash flow analysis for investment purposes.

A massive statewide crime control network is an envisioned computer application in the area of law enforcement. This would include data on automobile registration, driver registration, accidents, criminal records, crimes, etc.; all this would be stored in the computer and would be available instantly to local, state and national law enforcement officials.

Computer applications in the area of education include classload analysis, class scheduling, student body analysis, remote instruction, and research. School districts can and should greatly benefit from a strong centralized computer program, at least on the regional level, if not the state level.

A recently developed computer program should be of significant help to local government in the area of economic planning. This program will enable us to analyze the 1970 Montana census data, which contain millions of facts, in almost any way imagineable to help management to plan for the future growth of this state. Computer applications in all fields of government is limited only by factors of time, money and imagination. However, we must carefully analyze each application in terms of the cost involved, and the potential benefits to be received therefrom.

In conclusion, recent studies of computer utilization in various states from Massachusetts to California have shown great under-utilization of computer power and a waste of millions of taxpayers' dollars. Similar problems in Montana have been noted this morning. But the major findings in these studies can be summarized as follows:

---- Agencies do not generally have long-range plans for their data processing needs owing largely to the fact that no overall state plan has been developed.

---- Agencies expand their data processing capabilities and usage without regard to the needs and data processing capabilities of other agencies. These expanded plans for using data processing are developed solely to satisfy the agency's own demands.

---- Agencies are not generally very concerned about the location of the computer, provided they have access and control of the input and output and can be assured prompt processing of their work.

---- Agency data processing centers are not generally efficiently operated, nor do they have good systems design and adequate, proper documentation.

---- Agencies have difficulty recruiting and keeping better-trained data processing personnel because of the higher salaries generally paid in private industry.

The major recommendations contained in these nationwide studies can be summarized as follows:

---- Top management must face up to its responsibility and begin managing the computer rather than having the computer manage it.

---- The problems and needs of the entire state government must be considered when designing a system for any given agency. This means various state agencies must join in their computer efforts to avoid unnecessary and costly duplication in the development of data files.

---- The state needs a strong central staff of professional data processing personnel to develop and design a statewide information system and to establish statewide standards for computer languages, programming and documentation and computer operations.

---- Agencies must develop their capabilities to process input and output from remote terminals connected to a central computer.

---- Agencies should require competitive bidding for computer equipment by standards and specifications rather than by brand name. They should also develop a standard contract for data processing acquisition such as that recommended by the Council of State Governments.

---- State salaries should be increased and training programs developed so the agencies can attract and hold qualified data processing personnel.

We in Montana need to take the national findings and recommendations to heart. Our problems are small in comparison to those found in many states, because we are still developing our computer capabilities. If we can act in a wise and responsible manner now we can minimize or avoid many of the expensive mistakes made by others. The Department of Administration and the Data Processing Advisory Committee are giving serious thought to the long-range development of data processing in Montana state government. This is a big job for which there are no easy solutions. We are budgeting for a comprehensive study of data processing in Montana state government in the next biennium. As soon as the statewide system is developed, the state should address the question of local governments and

give them an assist in their problems as well.

The bipartisan constitutional amendment which limits the number of departments in state government will help bring related government activities, including data processing, together. This will enable management to better plan, control, and monitor their state data processing operations, while at the same time, eliminating inefficient and overlapping duplication of operation. The future of data processing in Montana state government is both exciting and challenging. Let us close ranks now and plan for the future as we move forward until we get a full return for our computer dollar, thereby making government more responsible to the needs of the citizens of this state.

STATE INFORMATION SYSTEMS: CENTRALIZATION VERSUS DECENTRALIZATION

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I should like to provide my answer to the topic question, "Should governmental data processing be centralized or decentralized?" My answer is both. The dichotomy in these alternatives is, in my view, more apparent than real. Like most issues of public policy and administration, the real choices lie not at the extremes but largely within the broad center area between them. In examining this issue, attention should be given to three factors: data processing technology; state and local government characteristics; and data characteristics. With these factors in mind, a reasonable approach to centralization and to the goals and scope of state information systems to be developed in the decade of the 70s can be formulated.

Data Processing Technology

A useful framework for considering the technology of computer-based systems is provided by five words: input, output, processing, storage, and communications. This framework is relevant because its elements are both appropriate to computer technology and descriptive of the functions that are performed in all management information systems, regardless of whether they are manual or mechanized.

Input is the collection of data and their entry into the system.

Output is the supply of data from the system to the users.

Processing is the manipulation of data according to rules that are provided.

Storage is the filing of the data awaiting use.

Communications is the moving of the data from one point in the system to another.

Each of these functions is performed in an information system consisting only of people, paper, and procedures--without any computer equipment whatsoever. These are the basic functions of an information system; however, they also provide a framework for considering current and prospective technology that is available to facilitate each of them.

Input. To provide input, computer systems use the familiar media of punch cards and paper tape; both are likely to continue without major technological change. Major promise, however, is held out by optical character reading equipment that reads printed characters directly into the computer. Although the volume of documents from which the data are read must be very large to justify this equipment economically, costs per

machine and per unit of work are dropping significantly and will continue to diminish. Several applications in state governments offer promise for this kind of input medium particularly those involving standardized formats where control can be exercised over the entry of data onto the form. Examples are many licensing and registration forms.

Output. At the oposite end of the system spectrum, output has traditionally been in the form of computer-printed documents. Printers driven by computers already operate at thousands of lines a minute, and speeds are increasing. Particularly significant for states is graphic display technology by which information can be provided in the form of lines, graphs, and charts as well as digital data on devices similar to television screens. Such devices are connected directly to the computer and enable the display of data from the computer's storage files. For example, unobligated balances in appropriation accounts of various agencies can be displayed, thus permitting an executive to know the exact balance on hand before committing the government to a proposed purchase. Computer systems will increasingly produce output in immediate or "real time" response to questions entered into inquiry stations. Executives and workers will thus be able to interrogate a broad data base in the computer and receive immediate answers in either printed or graphic form.

Storage. Computer storage of data has witnessed remarkable increases in capacity and accompanying decreases in access time to the stored information and in the costs of storing and accessing it. Today, costs and access time to large files of data in computers are less than a tenth of what they were five years ago. Multiple billions of information characters can be stored in digital form in computers, with any set of characters accessible in less than a single second. In fact, computer-based systems can now be designed without any significant technical constraints on data storage capacity. This technological capacity permits state and local agencies to formulate new information system concepts not limited by traditional data storage and access problems.

Processing. Processing is the execution by the computer of programmed rules or instructions. The best measure of processing performance is speed. In the mid-1950s, the speed of processing by computers was measured by milliseconds, or thousandths of a second; in the early 1960s, in microseconds, or millionths of a second; and now, in the early 1970s, computers are executing their instructions at speeds measured in nanoseconds, or billionths of a second. Accompanying the improvement in processing speeds is substantial increase in the internal memory capacity of the computer which enables it to handle more complex decision-making rules and to perform "timesharing" operations that involve carrying out several separate jobs concurrently. The capability of computers to process several programs of different users concurrently will permit smaller agencies who have hitherto avoided computer systems to rent the few hours of time each week or month that are sufficient to process their entire data processing work load.

Communications. Communications technology is advancing rapidly and promises to have major impact on computer systems used in state government operations. A major result will be the linking of devices for the remote input and output of information via telephone and microwave to centrally

located computer processing and storage facilities many miles away from the remote devices. This will enable many agencies throughout a state to use the same computer, both for large processing operations and for inquiries into central files of stored data.

Computer Programming. Computer programming, the process by which the computer is instructed in the rules by which it is to process data, is improving substantially. COBOL (Common Business Oriented Language) is now widely used by government agencies for file-oriented data processing. Particularly significant in terms of the use of the computer for management purposes is the refinement of many data base management systems which enable data to be entered into and retrieved from large data files. Since more and more activities of state and local agencies are likely to be oriented around large files of data, readily available, management-oriented computer programs for this purpose will be highly beneficial. Over one hundred such systems now exist and can be explored by states as possible sources of support for their computer-based file processing and management information systems.

Technological trends in computer equipment will increasingly enable states to put equipment components together in a way that best suits the needs of their systems. Indeed, computer equipment itself is likely to become a relatively smaller consideration in the design of state information systems. The equipment is improving at both ends of the size spectrum, and the user increasingly will have a broad range of choice so he need not make his system fit the limited equipment available, but rather can choose from a growing array of available devices for the functions of input, output, processing, storage, and communications. More and more, there will be small, inexpensive computer systems which will serve relatively small, self-contained systems completely, and there will be enormous improvements at the large end of the size spectrum where mass volume storage, faster internal processing, and spectacular advances in data communications will permit major reductions in unit costs and facilitate systems which serve multiple agencies. Many users--geographically remote from each other and from a common computer facility--will be able to share the facility, exchanging data with it and between each other.

State and Local Government Characteristics

As officials of state and local government, you are well acquainted with the characteristics of the organizations in which you hold office. My purpose is to underline some of the characteristics of state and local governments that I believe are particularly important to information systems development and computer use.

First, the several levels of state and local government have a large measure of legal, historic, and continuing independence. Recognizing that the state government is the constitutional source of local government authority and observing the trends in public administration, I believe it is likely that the state government will play an ascendant role vis-a-vis local governments during the decade of the seventies. Local autonomy will continue to be a real and proper part of state and local government, but I believe we will see the state assuming greater responsibilities both between the local governments and the Federal Government and with

respect to the performance of public services at broader geographic levels within the state.

Second, I believe that independently elected functional officials will diminish in number and influence over the next decade as central executives, such as governors and mayors, gain power and place growing emphasis on efficiency and the kinds of systems which encourage it. Thus, the relative independence of some functions of government from the remainder of the city, county, or state will tend to decline. An opportunity for integrating public services and taking full advantage of the capacity of modern technology can be expected to increase.

Third, I believe there will be increasingly apparent interdependencies among units, functions, and levels of government such that the data in one agency will be of more and more interest to other agencies. Thus, there will be a certain inclination toward data sharing because of a conviction that the growing complexity of problems requires a broader and deeper analysis of their fundamental causes. Thus, I see state and local governments moving toward greater power in the state government, more central executive control, lessening functional and local autonomy, and increasing interdependencies.

Data Characteristics

The basic ingredient in any data system is the data the system handles. State and local government have conventionally thought about and organized data according to their use, for example, police data, welfare data, accounting data, education data, etc. What has resulted from this practice? (1) there is extensive duplicate collection and storage of the same data; (2) data collected by one function for its own use are often unknown to other functions which could use the data if they were aware of their availability and if the data were in a form usable to them; (3) because of jurisdictional, mechanical, or procedural problems data are not efficiently shared among agencies; (4) the complete absence from any file of certain data useful to one department which could easily be gathered in the regular operations of another if the need for the data were known.

While data are gathered by state and local agencies for many different purposes, or functions, the data themselves are surprisingly often the same. This similarity is revealed in answer to the question "What basically do these data describe?" Approached from the answer from this question, state and local government data can be organized into two classifications, neither related to the functional departments that use the data but together including all the data that are used. The first class contains data describing the environment in which these agencies operate and for which they have responsibility. The second class contains data relating to the internal operations of the agencies themselves.

The environment in which state and local governments operate is composed of three categories of objects: real property, persons, and personal property. This environment is common to many agencies in state and local government, i.e., a parcel of land or a person fall within the purview of different agencies for different purposes. For example, the same parcel of real property may be taxed by a county, owned by a city, and provided with fire protection by a special district. Similarly, a person may be licensed to drive by the state, registered to vote by a county, and provided with welfare aid by a city. Usually, several functional departments of the same agency

provide different services to the same persons and property. The significant characteristic of the state and local government environment, therefore, is that it is common to many functions and agencies. Because these agencies direct their functions at persons and property, all environmental data they use describe persons and property and the events in which these objects are involved.

Internal data, as distinct from environmental, relate to the internal operations of the agencies themselves. These data describe the resources an agency has to perform its functions and the activities in which these resources are used. The resources are dollars, employees, equipment, and facilities, and most data in the internal category are used to account for these resources in various ways. Because each agency has its own resources and carries out its own activities, data in the internal category are generally limited in interest to the single agency concerned. Environmental data, on the other hand, because they describe an environment common to many agencies in state and local government, are frequently of multiple interest. This distinction, single interest on one hand and multiple interest in a common environment on the other, should be one of the fundamental principles guiding information systems design for state and local governments.

Centralization vs. Decentralization

Now let us examine the question of centralization versus decentralization of data processing in light of these three factors--technology, state and local government characteristics, and data characteristics. Of overwhelming importance in this examination is the need to distinguish among three quite different forms of centralization.

Centralization and Integration. A topic of classical concern in public administration, centralization takes on new meaning in the context of computer applications in government operations. In this context, three different types of centralization can be distinguished: (1) centralization of information, which concerns where and how data are stored; (2) centralization of management, which concerns how data are used; and (3) centralization of data processing equipment, which deals with the physical location of the machines. Centralization of information and equipment need not involve centralization of management. Centralized management occurs when a manager uses information and authority to direct the work of others; this is a use of the information. But, information from a central data storage or computing facility can be provided both to central and to various decentralized managers for their independent use. It should be clear, however, that once information is brought together in a computer-based centralized data system, it is more accessible to the central manager than previously when it was in decentralized systems.

This new accessibility may substantially affect hierarchical management relationships. Traditionally, information submitted for the attention of upper management moves up the organizational hierarchy. Intermediate managers remove certain of the detailed information, forwarding only more aggregated or specialized data to the attention of their superiors. Similarly, requests for information are sent down the organizational hierarchy and are dealt with at various subordinate levels. However, with centralized files of information easily and equally accessible to various management levels within the organization, higher management will have the opportunity to bypass middle management and go directly into the computer-based information system for answers to specific questions formerly provided

by middle managers. It will be important for higher management to give careful attention to conditions under which it should restrain itself from such direct inquiries into the computer-based information system in order to preserve for middle managers a role in filtering, analyzing, and interpreting such data. Since middle managers are usually in training for promotion to higher level positions, they must be given opportunity to exercise discretion. Overreliance of upper managers on information that can be obtained directly from the computer-based information system can thwart this vital management development function. The means by which managers exercise this "self-restraint" is likely to be the subject of increasing attention in public and private organizations as the use of the computer for management purposes becomes more widespread.

Centralization can also apply to the computer equipment itself. In the early days of computers, all of the machines were located in the same room; hence, the common observation that computer facilities were "centralized." However, as technology evolves toward placement of data input and output devices at locations throughout government agencies, the concept of equipment centralization must change. It can be expected, in fact, that there will be a mix of centralization and decentralization of computer equipment during the decade of the 70s, with remotely located input and output stations and centrally located processing and storage facilities, both linked by networks of communications lines.

Centralization of information is possible because of the technological capability of computers to store and retrieve enormous volumes of data. Very large data files can enable substantial reductions in the duplication of data previously maintained in separate files, and, more importantly, can enable more comprehensive information about individual events, objects, and conditions to be maintained. For example, all of the data about a governmental employee--his time worked, pay, retirement entitlement, vacation and sick leave accrual, job assignment, qualification, etc.--can be maintained within a single computer file rather than being divided between departmental files and the central files of the personnel office. Similarly, data about a particular county--its population, economic base, resources, public services, transportation system, etc.--can be brought together into a single file and presented in response to inquiries from officials in various departments. Thus, not all the information needed in any one department's operations need be maintained by that department, but can be stored centrally in a computer and made accessible through input/output devices located in departments. Although state and local agencies are likely to base their operations increasingly on files of data that are maintained centrally, other related data of unique interest to individual departments alone will continue to be handled completely within the department itself. This means that major attention must be placed on means or techniques for linking data in central and departmental files to assure that a high degree of accuracy is achieved in matching related data from the two sources.

Through this examination of factors affecting centralization of data processing and the meanings that should be given to the concept of centralization itself, I think you can see my conclusion emerging. It can be summed up in a very simple and pleasant concept--the concept of sharing. I believe we will see in state and local governments more and more shared equipment and more and more shared data On the equipment side, we will find the processing and storage technology centralized, the input and output devices decentralized. In data, we will find large pools of environmental data serving various agencies of state and local government, with the

attendant benefits of greater efficiency through reduced duplication and improved service through a better knowledge of the environment for which the agencies share public responsibility. With this conclusion in mind, let us consider different approaches to the development of data systems and application of computer technology in state and local government. My purpose is to suggest a framework for distinguishing alternative approaches and to offer some considerations relevant to choosing from among them and proceeding with the implementation. The framework has two dimensions: the scope of the systems, and their goals.

Scope

Scope concerns the boundaries of the data system and defines the suppliers and users of the data the system handles. In the state and local government context, I believe four broad alternatives of scope can be identified:

1. Intra-agency/Intra-functional

2. Intra-agency/Inter-functional

3. Inter-agency/Intra-functional

4. Inter-agency/Inter-functional

"Agencies" normally are organizations with elected leadership and considerable control over their own revenue, usually states, counties, cities, towns, or districts. "Function" describes a related set of end product government services usually organized into a department or group of related departments.

Here are some examples of state and local government data systems whose scope falls into each of these four categories:

Intra-agency/Intra-functional systems, wherein data are supplied and used within the same department of the same agency, are represented by utility billing, driver licensing and voter registration applications.

Intra-agency/Inter-functional systems, wherein the system handles data supplied and used in various departments of the same agency, are represented on the internal side by agency-wide payroll or retirement data systems. Environmental systems possessing this scope are represented by a "data-bank" serving several departments of the same city, such as developed in the city of Alexandria, Virginia.

Inter-agency/Intra-functional systems, wherein the system handles data supplied and used in related functions of different agencies, are represented in such systems as the New York State Identification and Intelligence System, the Los Angeles Youth Opportunities Board System, and the proposed regional management information program of the Metropolitan Washington Council of Governments.

> Inter-agency/Inter-functional systems, wherein the system handles data supplied and used by different functions in different agencies, have not yet been implemented to my knowledge. Our proposals suggest such a scope as a desirable long-range goal.[1]

Like most alternatives, these four blur at the edges, but I think they offer a useful framework, especially when related to data system goals. It is the mix of goals and scope that provides guidance for implementation action.

Goals

The goals to be considered here are those that relate to the data system itself. We are not concerned with the goals of the agency or function that the data system serves, even though it is recognized that these are a higher order of goals that the data system must support. By what alternative goals can a data system provide this support?

I believe three categories of data system goals can usefully be considered. First, the data system can be intended primarily as a tool in itself for directly carrying out complex decision processes. Here the computer is given decision rules and data; it applies the rules to the data and a decision or result is produced that is difficult to replicate by manual means because of the volume of data or complexity of the rules. In such a system the data are focused around very specific decision requirements, and an effort is made to answer "if...then" type questions according to the decision rules provided. For example, if population growth is x, and income levels are y, public recreation facilities can be expected to be z. Within state and local governments, this type of data system goal seems to be most highly developed in data systems supporting urban transportation planning.

A second data system goal is to design the data system as a tool primarily for providing better data to managers so that they can make better decisions and carry on better operations. In this approach, data are supplied and applied as well. Examples of this approach include the New York State Identification and Intelligence System and the Metropolitan Data Center System. In these systems, the goal is to supply decision makers with better data as a basis for their decisions. By "better" we usually mean data that are more current, more comprehensive, more accurate, and more relevant.

We try to specify the "really relevant data" by techniques both philosophical and mathematical, but despite our ponderings and our regressions, the final result is usually to put into a system the data we think are appropriate and those our boss wants, both criteria always circumscribed by what is available and the size of our budget. With respect to state government information systems, I think this approach is the best one we yet know. We will, I believe, be able to resolve the data requirements question conclusively only after much experimentation and experience

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[1] Edward F. R. Hearle and Raymond J. Mason, A Data Processing System for State and Local Governments, Englewood Cliffs, New Jersey, 1963.

by which a wide range of data are made available to decision makers and their actions and reactions are carefully examined. Therefore, the preferred approach is to provide a wide range of data within a state or local information system. Such data should support adequately the basic needs of some operating agencies and not merely provide a question-answering data base of interesting information to be interrogated from time to time.

I would stress that this data system goal does not restrict the operations of the data system to simple information retrieval alone. There can be as much data analysis as human ingenuity can design, but any decision action is a product of the human decision maker directly and not a product of the data system.

A third data system goal is that of reducing the cost of information handling. In routine examples, this means producing familiar clerical outputs at lower unit cost; for example, reducing the cost of issuing a payroll check or a driver's license. In less obvious examples, the total information handling cost may be reduced even though part of it, often the mechanized data processing part, is increased. It is important to remember that mechanized data systems often make the data processing costs more visible. Fulfilling this system goal, however, should reduce the overall cost of information handling with the system. Reducing the cost of information collection and storage is a particularly attractive opportunity within state and local governments.

In considering these data system goal alternatives, it should be remembered that the costs and benefits of data systems are always imbedded in a broader cost-benefit framework. It often makes economic sense to install an expensive information system if it improves the basic performance of the organizations and functions it serves. These data system goals represent alternative approaches to making such improvements.

With these four alternative scopes and three alternative data system goals in mind, let us turn to some of the factors to be considered in choosing from among them.

Factors Affecting Choice of Approach

Changing Technology. Continuing improvements in EDP technology permit new system concepts, particularly those that give users and suppliers of data access to files and computing facilities outside their immediate jurisdiction. The whole concept of centralized data processing equipment is going to change as devices for input and output become more and more decentralized while those for storage and processing serve more and more users from a central location. Of equal technological interest to state and local governments are improvements in low capacity, low cost computers that bring complete equipment systems within economical reach of smaller agencies.

In sum, EDP technology will become a relatively smaller consideration in automation plans as capability and flexibility expand. The user increasingly will be able to procure equipment to fit system concepts compatible with any of the scope or goal alternatives identified above.

Expanding Problem Boundaries. The problems with which state and local governments are concerned are becoming broader than the organizational jurisdiction of agencies responsible for dealing with them. It is being recognized more and more, for example, that police problems have their roots in a broader context than criminal behavior alone, and that urban renewal is not simply a physical problem. As these expanding problem boundaries become more widely recognized, traditional department data systems are going to become less satisfactory because they typically provide only the minimal information needed to perform routine, well understood, operational functions. Solutions to the problems for which the departments have responsibility will increasingly draw on data outside these traditional departmental systems. This is particularly relevant for research and planning functions that are rapidly increasing in importance within many agencies.

Federal Subsidies for Some Governmental Functions. Federal subsidies to state and local governments are program oriented and particularly aimed toward certain functions such as education, health, highways, and urban planning. Federal agencies granting subsidies are becoming increasingly interested in the data handling systems and activities of the agencies receiving subsidies, and it is likely that this interest will increase. In planning data system strategy, the attitudes and policies of the appropriate federal agencies must be considered if federal funding is a major part of the support for the program. Federal subsidy programs may tend to encourage functionally oriented data systems separately supporting each functional program subsidized. This may be a countervailing force to the development of inter-functional systems for handling data describing a common environment. In view of the expansion of problem boundaries, care should be taken that functional systems not be isolated from each other and from the general state and local governmental framework.

With these thoughts on scope, goals, and considerations to be kept in mind, let us turn to implementation strategies.

Implementation Strategies

Although experience and theory as yet give us no universal rules concerning data system development, the following considerations may be useful in choosing from among the alternatives available and proceeding with implementation.

With respect to scope, it appears desirable for state and local data systems to include both an *intra* and an *inter* feature. The nature of the data which these governments use and the emerging factors to be considered in designing systems make attractive a scope that is either interfunctional/intra-agency or intra-functional/inter-agency. I have a tentative impression that systems oriented toward property data can usually move best in the intra-agency/inter-functional approach, whereas systems oriented toward person data may best move in the inter-agency/intra-functional direction. In any case, it appears desirable to avoid inter-agency/inter-functional systems as an initial step; this is simply too big a bite to take.

Data system goals should be evaluated in light of systems scope. The third goal of reducing information handling cost can be solitary goal; it

is straightforward and appropriate to any of the scopes indicated. It is especially attractive for intra-agency systems because of the strong cost orientation of agencies as distinct from functions. The first goal, to imbed the system deeply in the decision process, should generally be fitted into a narrow data systems scope. Decision processes are always more complex to analyze and replicate in a data system than initially expected, and the scope of the data system involved should be narrow so the problem is manageable. The second data system goal--to provide better data for management decision--should not, in my judgment, be pursued alone. Data systems designed solely to provide data for decision makers are liable to fall into disuse because the value of data in decision making is as yet poorly perceived. It is preferable to graft the data requirements for decision making onto a system whose primary goal is the reduction of total information system handling costs. As we learn more about the value of data in decision making, it may be possible to design systems for this goal alone and have them succeed. At our present state of knowledge, however, it is better to provide the decision data requirements as an additional feature of systems anchored firmly on well-perceived operating requirements. This data system goal fits the scope of either inter-agency/intra-functional systems or intra-agency/inter-functional systems.

Whichever goal-scope combination is selected, it is important that the development of the data system be planned in phases rather than for complete implementation in a single step. The phases should have two purposes. First, each phase should be planned as an operating system satisfying in itself some real operating requirements. It should not simply be a point in the plan that is used to measure implementation progress, but should itself satisfy operating requirements. Second, each phase should be used explicitly to determine the operator's and manager's actual use of the information provided. The system can be thus modified appropriately based on the findings at each phase. Both purposes imply a period of operations at the conclusion of each phase before the next phase is undertaken.

Regardless of the goal-scope selection, a major effort should be made to provide compatibility so that future phases of the system or other related systems can be properly meshed with the system under development. I believe systems are going to grow toward the inter-agency/inter-functional form, largely because of the need for comprehensive information about a common environment shared by many state and local governments.

Finally, in developing data systems of whatever goal-scope combination, state, and local governments should be wary of moving into several new areas simultaneously. Avoid implementing new system concepts upon new and untried equipment with participants who are entirely new to electronic data processing. The newness of any one of these ingredients will give sufficient problems, and if all three are new together the problems are likely to be overwhelming. At least one ingredient in the effort--concept, equipment, or participants--should have a solid foundation of operational experience.

PANEL DISCUSSION

Moderator: Patricia Douglas

Moderator: In one day we've heard a great deal about national trends, local problems, problems of particular types of institutions and levels of state government, and hopefully we have some sense of the importance of planning as we take a look at the trends and somehow try to answer the issues. Having done all this, and having some sense of understanding, what is our next step?

Doyle Saxby: From the Department of Administration's point of view, this is a very critical question; critical from each user's point of view as well as that of state government. The problems have been brought into perspective in a very real way today. It will take a comprehensive effort and understanding by all users to decide where we are going and how we are going to get there. Because of this, we are planning in the Department of Administration and Data Processing Advisory Committee to approach the next legislative session and ask for a financial appropriation so we can actually study the problems and come up with a proposal to educate everyone involved in the need for planning to control the growth of our data processing.

Herb Schwartz: Perhaps an education program does come first; my own prejudice is that what we're really trying to do is to be as sensible as we can about deciding what to do, how to do it, and when to do it. What comes first? There is an answer for that--that's what planning is all about. The mission of planning is to make decisions, and the decisions that you want to make by planning answers the three questions of what, how and when. Planning is a fundamental decision oriented process, and maybe the first thing to do is for the state to bring together a total planning effort to develop a master plan. One of the speakers made a reference to the fact that the state does not have such a plan, and because the state does not, the individual agencies within the state--with a few exceptions--cannot do their own planning; they have no framework. They cannot plan privately, because that results in proliferation of processing. The first thing to do is to put together a first draft, an overall state plan. Then the agencies within the framework can attempt a plan to go along with the main state plan. They will find gaps and shortcomings in the state plan, so they can make corrections and send it back to the state administration for further revision. This is the way in which corporations plan, back and forth between departments. Top management sets goals, lower levels of management find how they are to get there, and the goals that cannot be met must be redrafted by top management. Basic planning should come first, or at least side-by-side with education.

Ed Hearle: Five things: get smart (education); look before you leap (planning); when you leap, leap in small hops within a framework; demand demonstrable results within a year; evaluate continuously and if nothing appears to be happening, cut off some heads!

Question: Since we do not now have a plan, and since there are great demands, what do we do in the interim?

Herb Schwartz: You should have a moratorium; not one of five years duration, but more like the moratorium they had in banking in 1933. It was very

painful, but I think you should lay low, even though this means a reduction in progress. When a demand for which imperative action must be taken is levied upon the governor's office it should be satisfied, because the moratorium will be indefinite. You shouldn't block all progress, but I do think you should make it very tough for people to obtain equipment till you have a plan.

Question: Somebody cautioned against paralysis by analysis, where the planning is interminable. In my opinion, the importance of planning is not so much to produce a document at the end, but rather to draw back from the day-to-day firefighting and think about the directions in which we must go. We need to build a consensus among the people affected by the plan, and this should not take more than two or three months. For that period of time, it's certainly wise not to foreclose an alternative that might become apparent by letting someone scoot in under the wire.

Herb Schwartz: It is unfair to say that you should have had a plan four or five years ago. Absolutely wrong. You must get into the problems first; you have to learn what it is you're planning, how to plan. You've got to have the problems of planning visible, or otherwise planning is just an exercise. You now recognize that you need a plan, and so you can build a plan. I think if you'd tried five years ago, you just wouldn't have been able to do it. For example, in my own organization, where we have a pretty big-sized effort going, we're just now beginning to really seriously plan.

Doyle Saxby: Assume that the plan has been written. Should we be buying or leasing equipment?

Herb Schwartz: I work for the Atomic Energy Commission. We have one of the world's biggest supplies of computers, and we have one of the world's biggest demands for computing. We own 99 percent of our computers. We're probably a little heavy on that, but today these machines don't really get obsolete, there's always someone around who wants them. There are economies to buying. I would answer your question: buy. Except, in those circumstances when you have a strong feeling in your bones or a visible reason for believing that you really are in a transitional stage and you know the first piece of gear is just not going to take the gas, but will last only for a year or two or three. Then I would recommend renting it, but otherwise, particularly with these so-called third generation computers, they're going to be around till the end of this decade, chugging away. In the Atomic Energy Commission, we are still running IBM 7094's, which are so obsolete that IBM no longer supports them; we have to fix them ourselves and buy parts for them in the open market. We're still running them and we own them; they've paid for themselves several times. I'd buy.

Ed Hearle: I think particularly in the system plans where there are certain specialized capabilities for certain departments, where the function is liable to remain fixed for a long time, it makes good sense to lock into something that is technologically adequate and will continue to be.

Question: When we start planning, should we plan for the hardware or the system itself to serve management?

Doyle Saxby: I would say definitely that the hardware uses are evident after all the planning is done, and after the hardware requests all come in. The real question in my mind, though, is that considerable thought should be given to the overall problem of how that equipment is going to

be used, or how it will tie in with the overall network. The total system should be addressed first, and then the equipment bought to fill the needs of the system.

Ed Hearle: In a similar situation, we know there's going to be an expansion in the demands for higher educational facilities, and yet we perceive on the horizon the need for a massive planning effort for the total educational system--curricular questions, graduate programs, etc.--so there is no simple answer. That is, you need more facilities because there's going to be a pile of kids, and you don't know exactly what they're going to study and you don't know exactly what the plan is going to come up with as to the content of the curriculum. I'm reluctant to pronounce any opinion on a principle as to whether you should systemate before you automate, or do you automate before you systemate. There is no clear dichotomy.

Herb Schwartz: The objective is to be as sensible as we can. We don't want to optimize; I don't believe we know how to optimize. We can plan for mathematical models, but not for real scrutiny. We're never going to know all the management principles on such an open kind of planning. If you're really good at this sort of thing, the plan you write two years from now will destroy the plan you've written now. You really can't lay out all the systems, the management systems, and then decide what complex of computers will fulfill these systems. You probably won't build half the systems you plan to build, and probably half the work you do will be to build systems you did not plan to build when you did the planning. You always have to be responsive to ideas and opportunities. You make your decisions to buy hardware early in the game, based upon what you can know about the obvious management systems you're going to build, with some kind of professional judgment on the capabilities and the size of the equipment that is required to satisfy the requirements or the management capabilities, and then you jump in! Your equipment will probably turn out not to be the optimum, and it never will. Don't worry about too long a run. There are risks involved, and government policy must take risks every day--political risks, professional risks, big risks. You have to gather together the people in the state who have learned something about the problems; they obviously know something, and they must make the decisions to go ahead, to plan and purchase the necessary equipment to carry out their plans. They call that planning under conditions of uncertainty.

Question: Now that we have heard that the rule or order of the day is to plan, who does it?

Doyle Saxby: Planning and education must go together. I believe that right now, at least as far as big government is concerned, planning is the responsibility of the Department of Administration. I'll have to admit, though, that we have not had the resources, but we're starting to develop those resources. The Advisory Commission has addressed this question from the very first meeting that I've been on the board, anyway, and we definitely recognize the need for the long-haul plan. In my opinion, the biggest problem is in higher education, and we have to come up with a decision.

Herb Schwartz: We have three questions to consider: when we're going to plan, how we're going to plan, and what we're going to plan. When we're going to plan is tomorrow. There are two levels in this planning. One

is the overview, and I would say, appoint a committee, with a tough chairman. The committee should consist of, first and imperatively, senior representation from the legislature. If you throw this thing to the technicians, they'll throw it back to you some time in an unpalatable way. The legislature is, in a certain sense, the people of Montana, and the people's interests should be preserved and represented. Someone from the Governor's office should be included, because the executive has some responsibility in managing. Then there should be two or three of the most senior administrative officials, the executive managers in the government, including your chief administrator. This committee would see to it that the planning is done. The committee must try to find out the various options that can be planned. Then, a task force is set up to work under the broad guidance of the top committee, or steering committee. The task force does the planning. This first planning should take in the neighborhood of three months. Long-term decisions are a painful, frustrating, useless kind of process. Then the task-force committee's report should be considered by the steering committee--men of maturity and judgment--which is used to making decisions much bigger than this. What I've presented is one possible management system for doing this planning. If the steering committee doesn't like what the task force comes up with, they can send it back for another few weeks. Probably what you'll come up with is one center for machinery in Helena, with all possible agencies hooked up to it, with the exception of the University System.

Question: Clarify in what sense Herb talked about centralization and its problems as compared to Ed's definition of equipment centralization.

Herb Schwartz: You're talking about different things. I believe in centralization of the hardware. Every time you double the money, you're going to get ten times the computer power. Proliferation of computers is crazy. The question is whether you want one big one, or two big ones, or a couple of regional ones, but the notion of every department having its own machine is madness. I believe in centralization within limits, but the university should have its own machine on each campus. (Remember, a university is gauged today by its students, its faculty, its library and its computer.) Don't get this mixed up with the administration in the state. Guys who are running the state have an enormous stake in the results of their work. Guys on the university explore and poke around--it's just an entirely different world. For management purposes, I believe highly in centralization, because of the returns, the tremendous economy there is in large machinery as against a number of small machines that cost the same amount of money. But, that's one kind of centralization, of computer facilities.

The second kind of centralization is of the systems themselves, and I'm dead set against centralized systems. I believe that different people should share in their own way the use of a common machine, but inside this machine are many different systems. There are some arguments to be made in favor of centralization of systems, i.e., economy, etc., but this means a centralization in management. There is no reason why the same machine can't do the payroll and other personnel or "people" information files separately.

Doyle Saxby: I'm glad Herb clarified the question as to hardware centralization; I'm sure this question was in many of your minds. We agree completely as to hardware centralization. On software, or systems centralization, I have to admit I have some question in my own mind. For instance, in our state, the counties have different federal and state identification numbers, and the agencies have their own identification numbers. I think

the coding systems should be standardized to a certain extent to avoid confusion and allow wider use of compatible systems and to keep the data in an organized, usable form.

Ed Hearle: I think one very useful result of the discussion is distinguishing types of centralization. We've spoken of equipment centralization, systems centralization, data centralization and management centralization. With respect to the equipment, I'm less of a centralist there than I am with data. The processing and storage devices should be centralized, but the input and output devices could be scattered around the various agencies in the state.

Question: Has an inventory ever been taken as to the needs of local government?

Charles Painter: The International City Management Association in 1966 and 1968 has made a national inventory of most government uses of data processing. The first two have been published in the Municipal Yearbook for those two years. One can get a feel for the local government use of data processing through this survey.

Question: Do you know of any place where local government units can pick a system in the computer systems area to help them in some sense to take the initiative toward planning, direction, productivity analysis, so forth, something that would help them plan the general framework?

Tom Dundas: Mitchell did such a study in Burbank, California in 1966-67.

Ed Hearle: The gentleman from the Montana League of Municipalities had in his hand a copy of a newsletter--Urban Information Systems Report, Vol. 1. It's the beginning of a series of reports which are going to be issued over the next three years reporting the experiences of the six cities which are now exploring the use of computers under a very generous federal grant.

Question: To Doyle and Herb: both of you have mentioned the fact that education and planning should go hand-in-hand. Being a member of the university community, the education hit me immediately. Could you expand a little on this problem?

Herb Schwartz: I just wrote an article on education in data processing, but it's outdated--it's more than two weeks old! I think what we really mean is education, not in how to program or engineer--partly that--but in alerting the people of the state to the potential and the problems. They should get a conceptual hold, have an understanding generally how these machines work, an understanding of the variety of their capabilities, an understanding of their costs, both to buy or rent, to run, to program for, to build systems for, to have an idea of what's involved in a system, the exquisitely painful problems of building people systems. The biggest problem is not the technology, the biggest problem is to get these cats to awaken. There are many people problems when you try to build information systems. The education should be one of perceiving the main issue, maybe a careful two or three day expansion of the sort of thing I try to do in one hour.

Doyle Saxby: Education doesn't always just involve telling the people what the computer does, it's also getting them to believe what it <u>should</u>

do. There are very real political implications, what is politically impractical will sometimes be overriden. We talked about crime control networks today. Drivers licenses and motor vehicle registration must be on computer before such a network can be built. Right now, our automobile registrations are hand processed. We must educate the electorate, the constituents as well as the people who are here on the job. They think we're going to be replacing people with more competent people and thus put people out of work. It really will put people out of work at the lower level right now if we automate automobile registration and this is a real education process and practical political problem. Registration should be automated, and we've got to convince the people that it should be automated, but there are some other considerations and this is where I think the education will have to come in.

REPORT AND RECOMMENDATIONS
TO
GOVERNOR FORREST H. ANDERSON
FROM
THE GOVERNOR'S INTERIM COMMITTEE
ON SCIENCE AND TECHNOLOGY

Background: The Governor's Interim Committee on Science and Technology was appointed by Governor Anderson on August 19, 1969. This action was preceded by the appointment, on March 31, 1969, of Dr. Roy E. Huffman, Vice President for Research, Montana State University, as Science Advisor to the Governor.

Activities: The first concern of the Governor's Interim Committee on Science and Technology was the preparation of a proposal to the National Science Foundation for funding of a Seminar Series on Science, Technology and State Government in Montana. A grant of $10,000 was awarded by the National Science Foundation. A series of four Seminars has been conducted as follows:

July 13, 1970, Great Falls, Potentials for the use of science and technology in agricultural development.

October 8, 1970, Helena, Potentials for the use of science and technology in state government.

October 20, 1970, Missoula, Potentials for the use of science and technology in forestry development.

October 30, 1970, Butte, Potentials for the use of science and technology in minerals development.

Conclusions: The dominating influence of science and technology in today's society and economy is well known. Presentations and discussions at the four Seminars focused on the specific implications of science and technology for three major sectors of Montana's economy - agriculture, forestry and minerals - and on the processes of State Government. In a natural-resource based economy, including emphasis on extractive industries, the use of science and technology of all kinds relates in many ways to man and his environment. Continued growth and development of Montana requires acceptable solutions to conflicts between developmental goals and environmental values. Research and education in the broadest context can contribute to the science and technology available for both economic development and the preservation of environmental values. Agencies of State Government, in cooperation with the private sector of the economy, should play an important role in the uses of science and technology.

Montana needs economic development to stem the net outflow of its productive citizens. The need is not for more people for the sake of numbers. The need is for more people to secure a viable and efficient balance between human resources and natural resources. The need is for more people to insure that Montana's wealth of space becomes even more of an asset and less of a cost factor in the very important goal of providing both the private and public goods and services necessary to the quality of life. As a relatively undeveloped State, Montana has a unique opportunity

to use science and technology to insure the maximum quality of life.

Recommendations: The following recommendations are presented for consideration by Governor Anderson:

1. That a permanent position of Science Advisor to the Governor be established on the Governor's Staff.

2. That the position be filled with an experienced scientist preferably with the Ph.D. degree in order that he may be professionally acceptable to the public and private scientific community.

3. That the Science Advisor be authorized to draw on the scientific expertise in the University System and the agencies of State Government and, where possible, in private industry.

4. That a permanent committee, commission or council on science and technology not be established at this time. The role of such a committee and its desirability should be more evident following the impending reorganization of State Government.

5. That the Science Advisor be authorized to constitute such ad hoc committees as may be necessary to consider questions and problems referred to him by the Governor and to make recommendations.

It is the consensus of the Interim Committee that the importance of science and technology now and in the future justifies a full time Science Advisor to the Governor. It is recognized, however, that it may be necessary in the beginning to associate the position on a part-time basis with another assignment in State Government or the University System.

Publications: This report and the recommendations can be published in such numbers and distributed in such a manner as may be desired by Governor Anderson. It is the intention, also, of the Interim Committee to publish the major papers presented at each of the four Seminars. These papers should be of considerable value to individuals and agencies concerned with the use of science and technology. Publication of these materials can be financed with funds remaining in the National Science Foundation Grant.

February 10, 1971

Approved by the Interim Committee -

Dr. John S. Anderson
Executive Secretary
Department of Health

Mr. Frank H. Dunkle
Director
Department of Fish and Game

Dr. Roy E. Huffman (Committee Chairman)
Vice President for Research
Montana State University

Dr. D. W. McGlashan
Vice President
Montana College of Mineral Science
and Technology

Mr. Perry F. Roys
Director
Department of Planning & Economic
Development

Mr. Ted Schwinden
Commissioner
State Lands and Investments

Mr. Douglas G. Smith
Director
Water Resources Board

Dr. Norman E. Taylor
Vice President for Research
University of Montana